ACI Supplemental Index 1959–1968

PUBLICATION

ACI

Supplemental Index 1959–1968

JOURNAL OF THE AMERICAN CONCRETE INSTITUTE

Index and synopses of papers published in Proceedings V. 56–65, July 1959 to December 1968

Supplements 55-Year Index 1905–1959

american concrete institute
P. O. BOX 4754, REDFORD STATION
DETROIT, MICHIGAN 48219

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Material other than papers are identified by the volume and an appropriate abbreviation. The abbreviations are:

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RECOMMENDED PRACTICE FOR HOT WEATHER CONCRETING (ACI 605-59).....56-1

Announcement of ACI standard

Separate copies of the standard available

ACI 605-59 supersedes Title No. 55-34

ACI COMMITTEE 605—July 1959, p. 1

This recommended practice provides information useful in minimizing detrimental effects of hot weather on concrete. Means are described for reducing concrete temperature by proper attention to ingredients; methods of production and delivery; and care in placement, protection, and curing. Information is given on the use of admixtures to reduce mixing water requirements and to retard setting. Emphasis is given to the importance of meticulous attention to the use of standard procedures in testing concrete made in hot weather.

RECOMMENDED PRACTICE FOR SELECTING PROPORTIONS FOR STRUCTURAL LIGHTWEIGHT CONCRETE (ACI 613A-59).....56-2

Announcement of ACI standard

Separate copies of the standard available

ACI 613A-59 supersedes Title No. 55-18

SUBCOMMITTEE ON PROPORTIONING LIGHTWEIGHT AGGREGATE CONCRETE, ACI COMMITTEE 613—July 1959, p. 2

This subcommittee report is intended as a supplement to ACI Standard "Recommended Practice for Selecting Proportions for Concrete (ACI 613-54)" and describes a procedure for proportioning structural grade concrete containing lightweight aggregates. This procedure does not require the use of values for specific gravity or absorption of the aggregates but utilizes a "specific gravity factor." Use of this factor is illustrated and examples are included for proportioning both air-entrained and non-air-entrained mixes.

RECOMMENDED PRACTICE FOR MEASURING, MIXING, AND PLACING CONCRETE (ACI 614-59).....56-3

Announcement of ACI standard

Separate copies of the standard available

ACI 614-59 supersedes Title No. 41-25 and 55-35

ACI COMMITTEE 614—July 1959, pp. 3-4

An outline of practices which have generally been found desirable for first class results in measuring, mixing, and placing concrete. Although many of these recommendations are applicable and should be used in connection with special types of concrete, i.e., lightweight, prepacked, etc., it is conventional concrete to which they specifically apply. Presents a comparatively high standard of practice rather than common practices; therefore recommendations are made on a "should" basis leaving to the user the responsibility of putting them on a "shall" basis in specifications for his work to the extent he considers worthwhile.

EFFECT OF BAR CUTOFF ON BOND AND SHEAR STRENGTH OF REINFORCED CONCRETE BEAMS.....56-4

PHIL M. FERGUSON and FARID N. MATLOOB—July 1959, pp. 5-24

Cutting off reinforcing steel bars in tension zones is shown to lower the shear strength of beams substantially, whereas bending up of bars shows no such ill effect. Exploratory study indicates that both bond stress and diagonal tension are acting to bring about the reduced strengths.

PRESTRESSED OVERLAY SLAB FOR SAN ANTONIO AIRPORT.....56-5

M. M. LEMCOE and C. H. MAHLA—July 1959, pp. 25-36

Design criteria, calculations, construction procedures, stress measurements, and performance history are given for two, two-way prestressed overlay slabs installed on taxiway of San Antonio International Airport. The 75 x 80-ft overlays, 4 in. thick, were placed on top of a damaged 6-in. slab. Prestress levels were 425 psi and 175 psi; both overlays were in good condition after 3½ years of service.

PROPERTIES OF NUCLEAR SHIELDING CONCRETE.....56-6

JAMES O. HENRIE—July 1959, pp. 37-46

General shielding requirements are discussed with particular emphasis on fast neutron shields. Concrete materials which are effective in meeting the requirements are outlined and the basic principles involved are explained. The concrete mix, type and source of materials, and strength properties of the shields of four similar nuclear reactors are compared. Effects on concrete setting time and strength of adding boron in the form of mineral colemanite and borocalcite and the counter effects of calcium chloride are described.

WIDTH OF CRACKS IN CONCRETE AT THE SURFACE OF REINFORCING STEEL EVALUATED BY MEANS OF TENSILE BOND SPECIMENS.....56-7

DAVID WATSTEIN and ROBERT G. MATHEY—July 1959, pp. 47-56

Tensile bond specimens simulating a segment of the tensile portion of a reinforced beam between two successive tensile cracks were tested to gain information on the width of crack at the surface of the reinforcing bar. Magnitude of crack width was estimated by comparing the over-all extension of the embedded bar with the extension of concrete adjacent to the bar. Crack width at the surface of a well-designed deformed bar was found to be significantly less than the width of crack measured at the exterior surface of concrete.

FIRE RESISTANCE OF A PRESTRESSED CONCRETE FLOOR PANEL.....56-8

G. E. TROXELL—Aug. 1959, pp. 97-106

General fire resistance features of conventional reinforced concrete and prestressed concrete are compared. Results are given of a 4-hr standard ASTM fire test on a 16 x 16-ft prestressed floor panel having an edge beam and an interior beam. Both beams and the 6-in. floor slab were post-tensioned and the cables were not grouted. Temperatures at several thermocouples on the steel cables and in the concrete were observed during the test. With a 1½-in. clear protection for the slab cables and a 2-in. clear protection for the beam cables no structural failure occurred during the 4-hr fire test. The temperature rise of the top surface of the 6-in. slab exceeded the allowable after 3 hr 51 min.

SURFACE COOLING OF MASS CONCRETE TO PREVENT CRACKING.....56-9

ROY W. CARLSON and DONALD P. THAYER—Aug. 1959, pp. 107-120

A method was developed which would permit the placing of extremely long monoliths of mass concrete without the occurrence of excessive tensile stress from cooling. The method is to maintain a low temperature of the surface concrete during hardening. Thus, compressive stress is produced when the surface warms, and subsequent cooling does not cause high tensile stress. The basic concepts of this method are described, detailed computations of stresses are given, and possible construction methods for accomplishing the reduced temperature are suggested.

FOLDED PLATE RAFT FOUNDATION FOR 24-STORY BUILDING.....56-10

IGNACIO MARTIN and SIXTO RUIZ—Aug. 1959, pp. 121-126

The folded plate raft foundation of a 24-story building 308 ft high is described. The influence of the subsoil conditions and the wind load are discussed. Costs are compared for a standard beam and slab raft foundation and the folded plate raft foundation.

GENERAL ELASTIC ANALYSIS OF FLAT SLABS AND PLATES.....56-11

JOHN F. BROTCHIE—Aug. 1959, pp. 127-152

A general method for elastic analysis of plates under transverse loads is described. Complex loading and support conditions, as in flat slab and flat plate structures, may be readily handled and are considered in particular. The method is suitable for both accurate analysis and design, and typical cases including concentrated loads, live loads on alternate panels, irregular supports, discontinuities, and settlement are discussed. The basis of the method was outlined in a previous paper, together with its application to regularly loaded internal panels of a flat slab structure.

EXPERIMENTAL INVESTIGATION OF FLAT PLATE FLOORS.....56-12

ISRAEL ROSENTHAL—Aug. 1959, pp. 153-166

This preliminary investigation was carried out on circular slabs, loaded centrally and eccentrically, representing the most dangerous portion of the flat plate floor around the supporting column. Eleven slabs in two sizes, 45 in. (116 cm) and 67 in. (170 cm) with a uniform thickness of 4 in. (10 cm), were tested and failed either in punching or in flexure. Shear reinforcement was found highly effective in preventing punching failure, which shows that thin, resistant slabs can be designed with the use of round bar reinforcement. Eccentric loading tends to reduce ultimate strength.

Hognestad's empirical equation, which considers the combined effect of shear and flexure in a centrally loaded slab, was used for slabs containing tension reinforcement only, resulting in satisfactory agreement with test data.

For these latter slabs diagonal tensile stresses were computed directly, taking into consideration the detached concrete cone of punching.

CREEP RECOVERY OF MORTARS MADE WITH DIFFERENT CEMENTS.....56-13

A. M. NEVILLE—Aug 1959, pp. 167-174

Values of instantaneous recovery and creep recovery of mortars made with different cements are presented. It appears that creep recovery is not related to mortar strength in the simple manner in which creep has been found to depend on this strength. Some data on the change in weight indicate that creep does not produce an additional movement of water from the cement paste into the surrounding medium.

LATERAL STABILITY OF REINFORCED CONCRETE BEAMS.....56-14

WILLIAM HANSELL and GEORGE WINTER—Sept. 1959, pp. 193-214

Some concrete design specifications, including the ACI Code, in various ways limit the distance between lateral supports of beams, presumably to safeguard against lateral buckling. The present investigation is intended to furnish some factual information on which to base such provisions. Ten tests on deep narrow beams have been carried out with unbraced lengths ranging from 28.8 to 86.4 times the beam width. No reduction in strength was observed over this range, showing the absence of lateral buckling. A tentative theory of lateral instability of reinforced concrete beams, including the effects of inelasticity and cracking, is given. It agrees with the tests in showing that present Code provisions are too restrictive, particularly for ordinary steel strengths. Theory indicates that closer lateral supports are required for high strength reinforced beams than for ordinary strength reinforcement.

CHICAGO'S 39-STORY R/C EXECUTIVE HOUSE.....56-15

HENRY MILLER—Sept. 1959, pp. 215-222

This 39-story, 371 ft high apartment house is supported on drilled caissons extending into bedrock. The slender structure of high strength concrete has heavy shear walls supplemented by massive rigid frame bents in the plane of the shear walls below the sixth floor. Below grade a grid of heavy girders ties together both the rigid bents and the foundation caissons. Cantilevered balconies serve three-fourths of the apartments.

LABORATORY STUDY OF PAVEMENTS CONTINUOUSLY REINFORCED WITH DEFORMED BARS.....56-16

MARTIN J. GUTZWILLER and JOSEPH L. WALING—Sept. 1959, pp. 223-246

Techniques and results of laboratory experiments on simulated continuously reinforced concrete slabs are given. Specimens 3 x 28 ft, 8 in. thick, were reinforced with deformed bars, variables being bar size, spacing, and depth, and total percent of steel. The slabs, cast with preformed transverse cracks in the testing region, were tested on an elastic subgrade having a modulus of approximately 160 lb per cu in. Vertical static loads simulated traffic loads and horizontal longitudinal loads were used to simulate stresses induced by temperature changes.

Results pertaining to slab deflections, crack widths, and stresses in reinforcement are emphasized. Significant findings are compared with field observations reported in the literature, and several criteria are suggested for optimum structural design of continuously reinforced pavements.

PRECAST UNITS FOR NEW ALUMINUM PLANT.....56-17

ROSS H. BRYAN—Sept. 1959, pp. 247-256

About 8000 precast, prestressed concrete units, including columns, brackets, beams, and floor slabs, were used in this project. Several intricate floor slab shapes were required, containing ventilation holes. The project covered an area of about 980 x 1075 ft.

Connections between all units, including columns, were made by bonding reinforcing bars into grouted cavities; welded connections were not permitted because of high voltage lines carried on the column brackets.

SULFATE ATTACK ON CONCRETE IN THE OSLO REGION.....**56-18**

JOHAN MOUM and I. TH. ROSENQVIST—Sept. 1959, pp. 257-264

In the Oslo region of Norway, alum shales containing small amounts of the unstable iron sulfide, pyrrhotite, produce an unusual form of sulfate attack upon concrete placed in or near these deposits, and cause deterioration if they are used as concrete aggregate. The ground water associated with the alum shales carries ferrous sulfate and produces severe sulfate attack and the precipitation of ferric iron compounds in concrete structures made with normal portland cement. Cements of low tricalcium aluminate content resist the sulfate attack but may be subject to attack by acid solutions produced when the ferrous sulfate is oxidized. Air-entrained concrete appears to be particularly susceptible.

ULTIMATE LOADS AND DEFLECTIONS FROM LIMIT DESIGN OF CONTINUOUS STRUCTURAL CONCRETE.....**56-19**

G. C. ERNST and A. R. RIVELAND—Oct. 1959, pp. 273-286

Ultimate loads and deflections permissible in individual members of a continuous concrete structure are dependent on the moment distributions. One of the methods used to determine this distribution is the limit design or plastic analysis. This paper gives a brief presentation of the pertinent features of the plastic theory. It defines essential terms and describes the static, kinematic, and uniqueness theorems which are used in conjunction with the analysis. It also discusses three methods used in determining moment distribution and gives accompanying examples and equations. This is followed by comparisons of concentrated plastic rotations and deflections for certain specific [illegible].

PROBLEMS AND PERFORMANCE OF PRECAST CONCRETE WALL PANELS.....**56-20**

VICTOR F. LEABU—Oct. 1959, pp. 287-298

The use of prefabricated concrete wall panels for curtain walls is gaining popularity in the building industry. However, the precast concrete wall panel in service can cause problems. While most walls of this type are trouble-free, defects in some precast walls are forcing those concerned to take a closer look at design and construction practices.

Since concrete is the basic material in the panels, the inherent problems for concrete must be controlled. Variation in color, inefficent U factor, and bulging are problems of precast wall panels inherited from concrete. Corrective measures for some of these problems are presented.

EFFECT OF ADMIXTURES ON ELECTROLYTIC CORROSION OF STEEL BARS IN REINFORCED CONCRETE.....**56-21**

YASUO KONDO, AKIHIKO TAKEDA, and SETSUJI HIDESHIMA—Oct. 1959, pp. 299-312

Describes experimental research on the effects of admixtures, fly ash and $CaCl_2$ with and without calcium lignosulfonate, on the electrolytic corrosion of reinforcing steel embedded in 5 ½-in. concrete cubes. The reinforcing steel was subjected, as anode or cathode, to direct current of 5, 10, and 20 v, or to alternating current of 20 v for 28 days, 3 hr each day.

Small amounts of $CaCl_2$, less than 1 percent of cement by weight, caused no harmful reaction under direct current of less than 10 v, and when $CaCl_2$ and calcium lignosulfonate were used together, the corrosion tendency was alleviated considerably even under direct current of 20 v. Alternating current of 20 v caused no corrosion in concrete containing the admixtures.

COMPARISON OF MEASURED AND CALCULATED STIFFNESSES FOR BEAMS REINFORCED IN TENSION ONLY.....**56-22**

BILL G. EPPES—Oct. 1959, pp. 313-326

In any study of mechanics of indeterminate structures stiffness plays an important role in analysis. Analysis leads to the determination of the redundant quantities, which in turn lead to the determination of the critical bending moments and shears. The factor EI, which is a measure of stiffness, is necessary for determining deflections of any elastic structure, be it statically determinate or statically indeterminate.

This paper is a presentation of the findings of an experimental measurement of stiffness (EI) for reinforced concrete beams. Measured values of stiffness are compared with the calculated values for nine beams.

It was found in this study that the measured values of stiffness decrease with increased bending moment, showing first a large value for stiffness for the lower values of moment and then a rather sudden transition to a lower value of stiffness for larger values of moment. The larger measured values compare reasonably well with the calculated gross section of a reinforced concrete beam with transformed area of steel and the lower values compare fairly well with the calculated net section of the reinforced concrete beam with transformed area of steel included.

RHEOLOGICAL BEHAVIOR OF HARDENED CEMENT PASTE UNDER LOW STRESSES.....**56-23**

J. GLUCKLICH—Oct. 1959, pp. 327-338

A set of simple static experiments with hardened cement paste is described to yield the deformational response of the material to low stresses. Using a mechanical analogy, this behavior can be described by the following elements connected in series: (a) a linear spring; (b) elements transmitting force by friction; (c) a body composed of a linear spring in parallel with a dash pot (a so-called Kelvin body); and (d) as in (c), except that the piston in the dash pot is made to move in one direction only by means of a nonreturn valve.

Alternatively, instead of (c) and (d), a body composed of a dash pot in parallel with a spring which includes slippage elements as in (b).

Creep behavior of the material is the superposition of two deformations: nonreversible creep with a relatively short time of retardation, and a reversible creep with a time of retardation one order of magnitude longer.

Quantitative results and the dependence of the various parameters on factors such as water-cement ratio and age are briefly mentioned.

CONCRETE TECHNOLOGY AND AGGREGATE PRODUCTION FOR ST. LAWRENCE SEAWAY.....**56-24**

M. R. SMITH and GORDON M. KIDD—Nov. 1959, pp. 361-376

Curing practices and high lift versus low lift construction were sources of the major differences between Canadian and United States practices on the St. Lawrence Seaway. Contrasting materials and mixing specification requirements are also reported. Both United States and Canadian aggregate production procedures and equipment are detailed.

STRENGTH OF THE CEMENT-AGGREGATE BOND.....**56-25**

K. M. ALEXANDER—Nov. 1959, pp. 377-390

Data from approximately 1000 determinations of portland cement-aggregate bond strength and portland cement paste strength are presented and analyzed. It is shown that at early ages, large differences can exist between the strength of the bond formed between the same cement and different aggregates. No evidence was found of significant cement-aggregate bond strength differences

between different samples of the same rock type. Cement-aggregate bond strength decreases with increasing water-cement ratio and alkali content, and increases with increasing age. All cement-aggregate bond strengths observed here for sawn aggregate surfaces were considerably lower than the strength of the adjacent portland cement matrix at 7 and 28 days. On the basis of these data explanations are suggested for some aspects of the process of tensile failure of plain concrete.

CRITIQUE OF CURRENT METHODS OF VARYING PRESTRESSING MOMENT IN PRETENSIONED PRISMATIC BEAMS.....56-26

JAMES R. LIBBY—Nov. 1959, pp. 391-408

Three methods currently used to vary the prestressing moment in the construction of prismatic pretensioned concrete flexural members are: bond prevention method, deflected pretensioned tendon method, and the combination of pretensioned and post-tensioned tendons. Each of these methods is described, and its limitations discussed. Comparison is made between the results which can be achieved with each method on a bridge stringer representative of the type commonly used in domestic composite bridge construction. Conclusions are made regarding the applicability of each of the methods and the research required to better apply the methods.

PRESTRESSED CONCRETE SHELL FOR GRANDSTAND ROOFS.....56-27

HENRY M. LAYNE and T. Y. LIN—Nov. 1959, pp. 409-422

Discusses in general terms the design, construction, performance, and economy of cantilevered prestressed thin shells which form the roof over the three main grandstands of Venezuela's new National Race Track in Caracas. The prestressed shells, which constitute the roof, are 100 ft above the ground floor and extend 90 ft from their supporting columns.

The design of the roof, after first attempting a rigorous mathematical analysis, was based on the assumption that prestressing had transformed the shells into horizontal columns with no bending. Prestressing practically eliminated cracks and deflections and reduced the shell thickness to 3 in. Further information on the performance and design are given along with the method and manner of prestressing and a comparative cost estimate between the design and one using only ordinary reinforcement.

BEHAVIOR OF A CONTINUOUS SLAB PRESTRESSED IN TWO DIRECTIONS.....56-28

A. C. SCORDELIS, T. Y. LIN, and R. ITAYA—Dec. 1959, pp. 441-460

Elastic behavior and ultimate strength of a continuous concrete slab prestressed in two directions were investigated. The slab, consisting of four panels, was supported at nine points and simulated a flat slab. Prestressing was accomplished by means of unbonded post-tensioned cables. Experimental values for moments, deflections, and reactions were compared with theoretical values obtained by the elastic plate theory and by approximate theories used in present design methods.

FACTORS AFFECTING PERFORMANCE OF UNIT-MASONRY MORTAR.....56-29

WILLIAM L. ZEMAITIS—Dec. 1959, pp. 461-472

Laboratory and field mortars, made according to ASTM C 270, were investigated for durability and then compared to determine whether laboratory tests could be used to check field durability. First, a laboratory investigation was made on durability of mortar mixtures using standard sand and two masonry cements meeting ASTM C 91 specifications, and using cement-lime-sand mixtures composed of eight different brands of limes. Three cement-lime-sand mixtures were investigated: 1:1:6, 1:1¼:6 and 1:2:9. Second, a field-mix investigation was made and it showed that about 13 percent entrained air was necessary to protect Types O and K, ASTM C 270 combinations, against freezing and thawing failure, and 11 percent was needed for Types M, S, and N. All cement-lime-sand combinations needed the addition of an air-entraining agent for durability. All masonry cement mixes were durable without the need of additional air-entraining agents. It was found that materials tested for durability in the laboratory with Ottawa sand at a flow of 110 ±5 showed good relationship to their durability performance at an average field consistency (130 ±5 flow). The field mixes used an ASTM median-graded field sand and a field mixer.

SELF-SERVICE PARKING STRUCTURES.....56-30

RICHARD C. RICH and WILLIAM J. ROUKE—Dec. 1959, pp. 473-486

The basic functional requirements for self-service parking structures—clean traffic flow, protection against obsolescence, gradual slopes and turns, and smooth transitions between changes in slope—are met economically with reinforced concrete. Cost comparisons are provided for several recently built parking structures.

Application of these general requirements is illustrated in the 630-car facility completed in Edmonton, Alberta. One-way traffic flow throughout is facilitated by elongated twin helical ramps nested within one another. A circular express down ramp also makes use of nested helixes. Foundation construction, beam and column design problems, radiant heating in slab, and a structurally separate stair and elevator tower are among building elements highlighted for discussion. A transverse expansion joint dividing the 320 ft long building is described, and structural details incorporated to provide for future expansion to 1000-car capacity are explained.

DESIGN OF L-SHAPED COLUMNS WITH SMALL ECCENTRICITIES.....56-31

L. S. MULLER—Dec. 1959, pp. 487-496

Proposed design method is applicable to L-shaped column sections symmetrical about a 45-deg axis, where eccentricities do not exceed the limit of cracking of the section. Three sets of tabulated values save computation work and shorten the design procedure. One example is worked out completely.

REACTION BETWEEN CARBON DIOXIDE GAS AND MORTAR.....56-32

B. KROONE and F. A. BLAKEY—Dec. 1959, pp. 497-510

Tests have been carried out to investigate the way in which carbon dioxide gas reacts with hardened portland cement in mortar. The influence of such factors as evaporable and nonevaporable water on this reaction was studied and the effect of different storage conditions on the shrinkage and the strength of the mortar is reported.

It was found that the absorption of carbon dioxide increases in the presence of evaporable water. The carbon dioxide thus taken up reacts with the lime compounds; some carbon dioxide is bound as calcium carbonate but some is held by some less powerful bond.

NUMERICAL METHOD FOR APPROXIMATE ANALYSIS OF BUILDING SLABS.....56-33

HOWARD L. FURR—Dec. 1959, pp. 511-542

A method for approximate elastic analysis of uniformly loaded slabs is developed. The method is applied to solid square and rectangular slabs, and to square slabs with square central openings.

The slab is divided into a grid of orthogonal strips assumed to be equivalent to the original slab. The strips are treated as beams laying along the center lines of strips which are rigidly joined at their intersections. The uniform load is divided into so-called equivalent concentrated loads applied at beam intersections and the grid

is deflected to an arbitrary position while carrying these loads. Joints are not permitted to rotate during deflection. Fixed-end moments developed by the deflection are distributed and vertical shears at each joint are computed. The ratio of summation of vertical shears at each joint to its applied load is computed and adjustments of the deflections are made until this ratio is constant throughout the grid. The deflected position under this condition is taken to be a solution condition and the distributed moments from such a position are divided by the constant ratio to give the bending moments in the beams due to the applied joint loads. Corrections are applied to account for the fact that the load is distributed rather than concentrated at joints. An attempt is made to account for plate action by considering both torque and bending in each strip of the grid. Elastic action and homogeneous material are assumed, and it is understood that the results are approximate due to these and other assumptions made in the development.

EVALUATION OF CONCRETE AND MORTAR MIXES.....**56-34**

WILLIAM A. CORDON—Jan. 1960, pp. 569-580

Properly proportioned concrete mixes should be designed to produce (1) quality, (2) workability, and (3) economy. Required quality and adequate workability are mandatory, but to completely evaluate a mix, its cost should be considered.

Useful information regarding concrete can be obtained by evaluating concrete mortars. This accomplished by evaluating the mortar from concrete mixes and correlating with concrete tests. New laboratory apparatus used in the study of concrete mortars is discussed.

Test results are included in which the following were evaluated: (a) aggregate grading, (b) aggregate particle shape, (c) portland cement, (d) pozzolans, (e) admixtures, and (f) water-cement ratio.

EFFECT OF DESIGN AND DETAILS ON CONCRETE DETERIORATION.....**56-35**

P. D. MIESENHELDER—Jan. 1960, pp. 581-590

Features of design or of construction of a concrete structure often are important contributing causes of concrete deterioration. Primarily, deterioration is a result of freezing and thawing. Such deterioration is often thought of as a consequence of the number of times freezing and thawing occurs, but in the examples pictured the major factor is the high degree of saturation which existed at the time of freezing. This high degree of saturation is usually a consequence of inadequate or no drainage provisions at critical points. This paper consists essentially of pictures of structures from a large area which illustrate examples and the wide extent of occurrence.

DESIGN OF BEAMS SUBJECT TO TORSION RELATED TO THE NEW AUSTRALIAN CODE.....**56-36**

HENRY J. COWAN—Jan. 1960, pp. 591-618

Formulas, accompanied by examples, are presented for determining torsional shear stresses, diagonal tensile stresses, and angle of rotation for plain rectangular and circular beams, T-, L-, and I-beams, with flanges, and for rectangular box sections. (Most of these equations are included in the new Australian building code.)

Examples and formulas are also given for determining the amount of torsion reinforcement required for both circular and rectangular beams. The relative qualifications and limitations of these formulas are discussed. The final part of the paper discusses maximum permissible stresses in torsion, combined torsion and shear, and combined torsion and bending. An annotated bibliography on the torsional strength of concrete is appended.

EFFECT OF SHEAR ON ULTIMATE STRENGTH OF RECTANGULAR BEAMS WITH TENSILE REINFORCEMENT.....**56-37**

GEOFFREY BROCK—Jan. 1960, pp. 619-638

The effect of shear on the ultimate moment of resistance of rectangular beams was investigated with the aid of small scale reinforced plaster beams. The modes of failure are defined and classified.

A hypothesis is developed that the effect of shear simply reduces the potential moment of resistance below that which would be developed in pure flexure. This hypothesis forms the basis of a simple method of predicting the ultimate load and mode of failure from the known bending moment and shearing force diagrams for any beam. It is checked by the results of experiments on beams under distributed load.

Results of the experiments are compared, where possible, with those obtained on reinforced concrete beams and published by other investigators.

DETERMINATION OF CALCIUM SULFOALUMINATE IN CEMENT PASTE BY TRACER TECHNIQUE.....**56-38**

TOSHIO MANABE and NAOYA KAWADA—Jan. 1960, pp. 639-650

To determine the rate of combination of gypsum with aluminate phases during the first few minutes of initial hydration period, a method using radioactive isotope sulfur-35 as a tracer was studied. The method consists of a combination of Forsen's extraction method with an isotope dilution method. Procedures are described and results discussed. From these results some considerations regarding the initial hydration process of portland cement are presented.

STRESSES IN DEEP BEAMS.....**56-39**

ELIHU GEER—Jan. 1960, pp. 651-662

Prestressed concrete I-beams with bearing blocks at their ends, when loaded to destruction failed in tension in the end block at its junction with the I-section. As this manner of failure is contrary to what known theories indicate, it was thought advantageous to investigate this matter more thoroughly. The purpose of this paper is to facilitate the design method of these end blocks by investigating stresses in deep beams, which are thought to be analogous to bearing blocks turned on their side.

The deep beam theory is in contrast with the flexural theory in that it is mainly one of distributing a localized force. One unusual feature of deep beams discovered in the course of the investigation is that the greatest tensile stress occurs *not* at the midspan but near the face of the support. Another interesting feature is that maximum stresses are a function of the magnitude of the load and not its location, e.g., the stresses caused by a load at the center of the beam are almost of the same magnitude as when the load is placed near the support. This study was limited to deep beams whose height was at least 0.5 of its clear span.

DESIGN OF PRESTRESSED LIFT SLABS FOR DEFLECTION CONTROL.....**56-40**

EDWARD K. RICE and FELIX KULKA—Feb. 1960, pp. 681-694

Prestressed concrete lift slabs have been used successfully, not only as an economical method of construction, but also as a medium to obtain flat slab buildings that have no deflection or camber.

The analysis of a flat slab can be extremely complex. The "beam method" has been developed as an approximate but applicable method of design. By this analysis, slabs may be designed for proper behavior and strength without the use of the more complicated plate theory.

ROGER DIAZ DE COSSIO and CHESTER P. SIESS—Feb. 1960, pp. 695-736

Forty-nine simply supported beams and 24 frame members were tested under several different types of loading. These included: two-point loads, midspan concentrated loads, uniform load, and axial load. The frame members and 18 simple supported beams were tested under uniform load. Ten of the beams under midspan concentrated loads were tested with an axial load of 20 kips. Special emphasis was placed on the effects of axial and uniform loads on shear strength and behavior of the members. Other variables were concrete strength, steel percentage, and span length.

The test results are given, discussed, and correlated. The use of the inclined tension cracking load as a measure of the useful shear strength of the members is advocated, and a procedure is given for its determination.

HENRY T. TOENNIES—Feb. 1960, pp. 737-756

Research to develop a process of artifical carbonation of concrete masonry units is described. A process of hastening carbonation (preshrinking) of masonry units would eliminate subsequent atmospheric carbonation and attendant shrinkage after the units were in a wall. Research was prompted by the feasibility of artifically carbonating concrete masonry units, using as a source of carbon dioxide the flue gases from combustion in steam boilers adjunct to steam curing.

Flue gas carbonation effected reductions in early-age drying shrinkage of masonry units. Reductions varied with carbonation time, temperature, and precarbonation moisture condition of units. Greatest reductions accompanied treatment at elevated temperatures immediately after completion of steam curing. Early-age shrinkage benefits due to carbonation were reflected in total shrinkage with time during 10 months of atmospheric exposure.

The effect of carbonation on other measured physical properties of concrete masonry appeared minor.

M. A. GOUDA—Feb. 1960, pp. 757-774

Presents a method for determining torsion and bending moments in concrete beams and slabs connected monolithically. Solution of the problem is based on the elastic torsion theory where the effect of the torsional rigidity of beams and slabs is taken into account. Beams are assumed to be homogeneous with their ends rigidly fixed.

Different cases investigated included: outer beam subjected to a cantilever moment, marginal beam, effect of beam end rotation, and effect of beam deflection.

Formulas and practical curves are given for a direct determination of the torsion in the beams and the moments in the slabs.

INGE LYSE—Feb. 1960, pp. 775-782

In the design of prestressed concrete structures it is necessary to take into account the effects of shrinkage and creep, which cause a reduction of the initial prestressing forces. This paper reports on tests of the four major factors that contribute to shrinkage and creep. Equations are derived, based on the data obtained from the tests, for determining the combined shortening effects of creep and shrinkage.

I. L. TYLER—Mar. 1960, pp. 825-836

During 1941 and 1942 four experimental installations of test piling were driven, three in sea water and one in fresh water, for studies of concrete performance. One sea water exposure was in the east mooring basin of Cape Cod Canal, so as to evaluate the effect of exposure in a cold climate. A fresh water exposure in similar climate was constructed at the confluence of Esopus Creek and the Hudson River at Saugerties, N. Y. Two other sea water exposures were in the mild climates of Florida and southern California. Twenty-two of the 27 Long-Time Study cements were used in three eastern exposures; seven were used in California. After more than 15 years, significant trends in performance are developing, not all of them along the anticipated lines of the investigation of cement performance but still of much more than casual interest to users of concrete in marine construction.

CLARENCE W. DUNHAM and HANS GESUND—Mar. 1960, pp. 837-852

A numerical method is developed for finding the moment at which the tensile reinforcement in a reinforced concrete beam will just reach the yield point if the beam is underreinforced, or at which the concrete will reach its ultimate strain if the beam is over-reinforced. Curves are drawn of M/bd^2 versus p for a variety of assumed concrete stress-strain curves. The method is also applied to eccentrically loaded columns, and curves of yield load versus eccentricity (both in dimensionless form) are drawn for square, rectangular, and circular columns with a variety of percentages of reinforcement and various assumed concrete stress-strain curves. The extension of this method to columns with bending in two directions is outlined.

M. F. KAPLAN—Mar. 1960, pp. 853-868

An experimental investigation has been conducted to determine the effects of voids due to incomplete consolidation on the compressive and flexural strength, ultrasonic pulse velocity, and dynamic modulus of elasticity of concrete.

Concrete mixes having cement:aggregate:water ratios of 1:3:0.35, 1:6:0.50, and 1:9:0.66, by weight, were used to make 20 x 4 x 4-in. beams and 6-in cubes for resonant frequency and flexural and compressive strength tests. The tests were done after 7, 28, and 91 days. Pulse velocity measurements were also made on all specimens before carrying out the other tests. The amount of consolidation was varied by vibrating the concrete for different lengths of time. The maximum void content was 32 percent.

The effects of incomplete consolidation on compressive and flexural strength, pulse velocity, and dynamic E are reported and the interrelationships between these properties examined.

TUNG AU and DONALD L. BAIRD—Mar. 1960, pp. 869-880

Laboratory tests were conducted to determine the bearing capacity of square concrete blocks whose area is 2 to 16 times the contact area and whose depth equals either full or half width of the block. Two concrete mixes with different maximum aggregate size were used for a total of 60 test specimens. The test results were plotted in

dimensionless coordinates, with the ratio of bearing capacity to unconfined compressive cylinder strength as ordinate and the ratio of block area to contact area as abscissa. A rational interpretation of the test results is suggested.

CONSOLIDATION OF CONCRETE.....56-49

ACI COMMITTEE 609—Apr. 1960, pp. 985-1012

The first chapter reviews briefly the history of consolidation of concrete. This is followed by a discussion on advantages of vibration, types of equipment and operating frequencies, forms, and concrete mixes (structural,. mass, pavement, floor, lightweight, heavyweight).

The second chapter is devoted to recommended practices and gives information on amount of vibration, effect on entrained air, overvibration, revibration, and use of retarders. Recommended techniques are outlined for structural concrete, slabs, mass concrete, pavement, (thick, thin, and reinforced), earth-moist concrete, lightweight concrete, heavyweight concrete, concrete block, and precast products.

INTERNAL FORCES IN UNIFORMLY LOADED HELICOIDAL GIRDERS.....56-50

A. C. SCORDELIS—Apr. 1960, pp. 1013-1026

General equations for determination of redundants at midspan of a uniformly loaded helicoidal girder fixed at its ends are given. Tabulated results, for these redundants, obtained with the aid of a digital computer, are presented for 510 different cases, the variables being horizontal angle, angle of slope, and cross-sectional dimensions. The effect of these variables on the redundants and the maximum internal moments and torques is discussed.

PROPERTIES AND USES OF HIGH-MAGNESIA PORTLAND SLAG CEMENT CONCRETES.....56-51

NIKO STUTTERHEIM—Apr. 1960, pp. 1027-1046

Some properties of portland blast furnace slag cements, made from slags having from 13 to 20 percent magnesia, are described, in particular those composed of 50 percent slag and 50 percent portland cement clinker plus gypsum. Two ways of blending these constituents are: (a) intergrinding the granulated slag, portland cement clinker, and gypsum in one milling process; (b) grinding portland cement (clinker plus gypsum) and granulated slag separately and then blending them, e.g., in the concrete mixing operation.

Blast furnace slag for this study was derived from three different plants, each of which uses dolomite as fluxing material in its blast furnaces. The composition and properties of slags and of cements made from them are discussed; the effects of dry and wet grinding of slag, of fineness of grind, and of portland cement content were determined experimentally. Autoclave expansion results were invariably low.

The performance of concrete made with these cements is given in respect to workability, shrinkage, dynamic modulus of elasticity, Poisson's ratio, and compressive and flexural strengths. Values for a portland cement concrete are given for comparison. The results show that the slag cements have good cementitious properties. No correlation between compressive strength and any of the commonly-used hydraulic indices could be found.

Some examples are given of full-scale constructional applications of portland blast furnace slag cements made from high-magnesia slags.

UTILITY POLES OF REINFORCED AND PRESTRESSED PIPE.....56-52

E. WOLMAN—Apr. 1960, pp. 1047-1058

Design of utility poles of circular section constructed of reinforced concrete and prestressed pipe, which are subjected to relatively high bending moments and to negligible axial forces and shear stresses, is considered. Forces acting on simple, corner, and other poles are considered, as well as how to distribute the reinforcement to obtain best results. Design formulas are suggested.

DESIGN OF UNSYMMETRICAL REINFORCED CONCRETE SECTIONS.....56-53

A. SIEV—Apr. 1960, pp. 1059-1070

Reasons for loading these beams in the plane of the major principal axis are discussed. A method for determining this axis for unsymmetrically reinforced concrete sections in cracked-elastic and cracked-plastic stages is presented. Design equations are derived, followed by an example problem.

ACI IN AN EXPANDING ROLE.....56-54

PHIL M. FERGUSON—May 1960, pp. 1097-1104

Phil M. Ferguson, professor of civil engineering, University of Texas, Austin—retiring president of ACI—points to the expanding role of ACI internationally and the increased activity of technical committees. The industry is reminded of the problems needing solution, three examples being unformity of concrete strength and properties, adequate inspection, and industry research.

RESEARCH, BUILDING CODES, AND ENGINEERING PRACTICE.....56-55

CHESTER P. SIESS—May 1960, pp. 1105-1122

The function of research and practice as sources of knowledge, and the utilization of this knowledge in the preparation of codes or specifications are considered from a philosophical and historical point of view. Examples drawn from current or past ACI Building Codes are cited to illustrate the roles played by research and by engineering practice in the drafting or revision of codes.

DIFFERENTIAL SHRINKAGE IN COMPOSITE BEAMS.....56-56

HALVARD W. BIRKELAND—May 1960, pp. 1123-1136

Due to normal aging and curing processes, shrinkage occurs in a slab when it is cast onto precast prestressed beams. This shrinkage induces stress into the composite beam and slab construction causing the beams to deflect. An analytical method is presented for predicting the sag. Equations are given for stresses on slab and beam section, shear and moment at the interface, and slope and deflection. This is followed by comparison of computed values with actual values obtained from full size test beams. Values are in close agreement.

PLASTIC FORMS FOR ARCHITECTURAL CONCRETE.....56-57

J. A. HANSON—May 1960, pp. 1137-1148

Pleasing and unusual architectural effects in concrete are being obtained by the use of forms made of plastics. The architectural treatment may consist of both surface finish and bold pattern decoration. The concrete surfaces can be either glossy-smooth or textured. In either case, the surface is free of open air and water pockets. No special facing mixes, no parting agents, and no polishing or grinding are required. The extremely fine smooth finish of plastic-formed concrete greatly improves the attractiveness of integral colors, and due to the high reflectivity, smaller amounts of pigment are required to obtain a given color intensity.

A considerable number of reuses are obtainable with the plastic forms, thus reducing the cost through multiple use. Laboratory tests established optimum curing conditions for this type of architectural concrete. It was found

that temperature control is important if a high degree of reflectivity is desired.

Although the present development of plastic forms was initiated only 3 years ago, a considerable number of applications have been made in the field. Several of these are described.

EFFECT OF FLOOR CONCRETE STRENGTH ON COLUMN STRENGTH.....56-58

ALBERT C. BIANCHINI, ROBERT E. WOODS, and CLYDE E. KESLER—May 1960, pp. 1149-1170

Forty-five specimens representing portions of the corner, edge, and interior column and floor sections of a typical structure were tested under axial compressive loads and the results analyzed to determine the following: (1) how large a differential in column concrete strength and floor concrete strength could be tolerated without decreasing the load-carrying capacity of the column, and (2) the allowable load-carrying capacity of the column if this differential is exceeded. The following variables were included: type of specimem, column concrete strength, and floor concrete strength.

From the analysis of the test results, a procedure was developed for computing the ultimate load of a column in which the column concrete is intersected by floor concrete. These limited tests indicated that the column strength is a function of the ratio of column concrete strength to floor concrete strength and the number of restrained edges tributary to the column. No reduction in column strength occurred for ratios of column concrete strength to floor concrete strength up to 1.4 for all types of specimens and up to 1.5 for most types of specimens.

PERFORMANCE AND DESIGN OF SPECIAL PURPOSE BLAST RESISTANT STRUCTURES.....56-59

ROBERT A. WILLIAMSON—May 1960, pp. 1171-1190

The structures housing scientific equipment used in nuclear tests in the South Pacific are discussed from the standpoint of service experience and structural design approach. Two structures, one sited below ground, and the other above ground, are described, and damage history is briefly discussed. The general procedure currently used in the design of these structures is presented and illustrated with a numerical example.

ELASTIC ANALYSIS OF SHEAR WALLS IN TALL BUILDINGS.....56-60

EMILIO ROSENBLUETH and IGNACIO HOLTZ—June 1960, pp. 1209-1222

Often the moment-resisting frame of a tall building is supplemented by shear walls running the full height of the building. Under lateral loads, interaction between the shear walls and frames, due to flexural deformations of the walls, leads to complex analytical problems. These are amenable to an approach by successive approximations similar to that of beams on elastic foundations. If the building is fairly symmetrical, a good first approximation can be obtained from the solution of a differential equation which is based on the assumption of complete uniformity. The solution to the differential equation is given as a set of graphs. The authors apply the method to one particular example. A numerical method is set up to systematize successive cycles of iteration and it is found that extrapolation from the first two cycles supplies almost exact results.

METHOD OF ASSESSING PROBABLE FIRE ENDURANCE OF LOAD-BEARING COLUMNS.....56-61

J. H. CLARKE—June 1960, pp. 1223-1242

This paper gives two methods of assessing the probable fire endurance of load-bearing reinforced concrete columns subjected to the standard fire resistance test. A column during a test may support a load well below the permissible design load and therefore the fire endurance period may be expected to exceed the fire resistance rating allocated according to the size of the column, thickness of the cover, reinforcement, and the load.

The suggestion is tentatively put forward that designers may be permitted to design a column according to the load carried, including a safety factor. Then they may modify the design by the methods given in this paper if the requisite fire resistance is not obtained.

The column sizes dealt with are 15 x 15-in. to 20 x 20-in. as this range of column sizes occurs frequently in design practice and information on the smaller sizes is more readily obtainable.

MULTIPURPOSE BUILDING OF PRECAST THIN-SHELL PANELS.....56-62

ARSHAM AMIRIKIAN—June 1960, pp. 1243-1252

An assembly of simple precast panels, connected together by bolts and welded inserts, provides the structural framing of a single-story gable-roof building, suitable for many uses. The panels are ribbed, consisting of a thin slab and peripheral stiffening members. Arranged for 4-ft modular framing, two pairs of panels—one pair placed in the roof and the other in the sidewalls—compose a building segment 4 ft wide.

Framing arrangement, design, assembly, and jointing are discussed. Information is also given on strength tests and service behavior of an experimental building built of these panels.

EFFECT OF TENSILE PROPERTIES OF REINFORCEMENT ON THE FLEXURAL CHARACTERISTICS OF BEAMS.....56-63

ROBERT G. MATHEY and DAVID WATSTEIN—June 1960, pp. 1253-1274

The effect of magnitude of steel stresses and the nature of the stress-strain characteristics on the center deflection, strain in the concrete, widths and spacing of cracks in the region of constant bending moment, load carrying capacity, and the manner of failure were investigated in a series of flexural beam tests. This series consisted of 12 rectangular concrete beams reinforced with six different types of steel bars with yield strengths ranging from 42,500 to 104,300 psi. The ratio of reinforcement was proportioned inversely to the yield strength, thus providing equal resistance to yielding under tensile forces.

Failure occurred in all the beams at approximately the same load. Test results were compared with values computed with the "straight line" and "ultimate strength" theories. The relationship between the computed steel stresses and the center deflections, width and spacing of cracks, and strain in the steel and concrete was determined for the six types of steel bars.

CARBON DIOXIDE IN HYDRATED PORTLAND CEMENT.....56-64

W. F. COLE and B. KROONE—June 1960, pp. 1275-1296

A study is made of the way in which carbon dioxide is held in carbonated samples of portland cement mortar and of calcium silicate hydrate using differential thermal, thermogravimetric, and x-ray diffraction methods. The results indicate that the carbon dioxide is chemically bound as calcium carbonate, largely in the form of poorly crystallized vaterite, aragonite, and calcite, and not as a silicate mineral. The carbonate minerals are intimately associated with the siliceous residue that results from the carbonation of the hydrated cement minerals. They react with this residue when the samples are heated to yield the unstable larnite (β-$2CaO{\cdot}SiO_2$) which, at room temperature, is discernible in a rapidly cooled sample. The temperature of the reaction is well below that at which well-crystallized calcite and quartz react to produce wollastonite ($CaO{\cdot}SiO_2$). Some conclusions are drawn as to the mechanism by which the carbonation of cement minerals could take place.

V.57 SYNOPSES

Institute papers and reports of Proceedings V. 57 (July 1960-June 1961 ACI JOURNAL)

HUBERT RUSCH—July 1960, pp. 1-28

This paper is directed toward formulation of a general flexural theory based on a careful study of all important factors regarding the properties of concrete. The fact that strength and deformation of concrete depend on time is considered. The theory is based on recent tests permitting determination of the behavior of the compression zone in flexure for continuous load increase at different strain rates, and for constant sustained load. Having derived stress-strain relationships for these various types of loading, other factors were studied systematically, such as effect of concrete strength, position of neutral axis, and shape of cross section. The general theory developed is primarily a study of the true behavior of structural members. Since simplified assumptions are avoided, it naturally does not lead to simple formulas such as are desired for structural design. The theory fulfills the important function of furnishing a reliable method for the evaluation of simplified design formulas. It is also possible, however, to present all new concepts and results of this theory in the form of a simple diagram which can be used for the solution of design problems for selected cross sections ranging from pure bending to pure compression, regardless of concrete quality and the type of steel used, and independent of whether prestressing is applied or not.

WEI-WEN YU and GEORGE WINTER—July 1960, pp. 29-50

The availability of high strength steels and concretes and the acceptance of ultimate strength design have made it possible to utilize much shallower flexural members than in the past. The larger deflections of such members make it imperative for the designer to possess simple and reliable methods for pre-computing the expected deflections. This refers not only to deflections immediately upon load application, but also, and particularly, to long-time deflections under sustained loads. This paper presents two simple methods, each, for calculating instantaneous and long-time deflections under service loads. The methods are checked against the results of 175 deflection tests from nine different investigations. Agreement is found to be uniformly satisfactory for design purposes.

A. PADUART and J. VAN DOOSSELAERE—July 1960, pp. 51-72

Belgian civil engineering was represented at the Brussels International Exhibition by an original and audacious reinforced concrete structure. It was a reinforced concrete cantilever beam ("arrow") 270 ft long, balanced by a triangular shell roof with 95-ft sides and a thickness of 2½ in. The whole construction was supported by only three columns. Architectural, structural design, and construction features are described.

JOHN E. BOWER and IVAN M. VIEST—July 1960, pp. 73-98

Tests of two series of reinforced concrete beams without web reinforcement were made to investigate the behavior in shear of restrained beams. One series was designed as a study of the effects of variations in the ratio of maximum negative moment to the maximum positive moment (moment ratio). The other series was concerned with the effects of variations in the ratio of maximum moment to shear (moment-shear ratio $= M/Vd$).

The tests have shown that the effect of shear on the behavior of restrained beams is essentially the same as that observed for simple beams: the shear affects the load-deformation characteristics and the strength of a beam through the formation of diagonal tension cracks. The first diagonal tension crack forms at a section subjected to both moment and shear and located between the point of contraflexure and the section of maximum moment. An analysis of the test data has shown that the initial diagonal tension cracking strength is a function of the moment-shear ratio rather than of the length of the shear span.

Large variations were found in the strength beyond the initial diagonal tension cracking loads even for companion specimens. This finding supports earlier suggestions that the strength in excess of the diagonal tension cracking load is of little practical value.

Equations are presented for the initial diagonal tension cracking strength and for the shear-moment capacity.

LUIS P. SAENZ and IGNACIO MARTIN—July 1960, pp. 99-106

Design and construction features are described for a series of reinforced concrete slab highway bridges with inclined columns and 59, 62, and 79 ft maximum spans. The economies and the advantages of slab deck bridges for overhead crossings and underpasses are discussed.

LEWIS H. TUTHILL—Aug. 1960, pp. 129-138

Some of the most important aspects of conventional methods of concrete repair and restoration are reviewed, compared, and emphasized. Particularly, factors affecting bond, permeability, cracking, durability, and appearance are discussed.

It is particularly emphasized that fully satisfactory repairs are seldom obtained without thorough inspection to insure strict adherence to all parts of the specified procedure.

EARL J. FELT—Aug. 1960, pp. 139-154

Patching of distressed areas of concrete pavements with bonded concrete can be accomplished successfully if established principles are followed. Most important is a

clean, sound, old concrete surface. In addition, high quality grout and concrete, and first class workmanship are essential. Suggestions are given for cleaning and preparing the old surface, for grouting, and for placing concrete.

PREPAKT METHOD OF CONCRETE REPAIR.....57-8

RAYMOND E. DAVIS—Aug. 1960, pp. 155-172

The prepakt method is used both in the restoration of old concrete and masonry structures and in certain types of new construction such as underwater work and work where the proper placement of conventional concrete would be difficult or impossible. The method is described, as are also the materials employed. The types of repairs for which the method is particularly well adapted are given. Mix proportioning methods are discussed. Methods of test for fresh prepakt grouts and hardened prepakt concrete are given. The properties of prepakt and conventional concrete are compared.

REPAIR OF DAMAGED CONCRETE WITH EPOXY RESINS.....57-9

BAILEY TREMPER—Aug. 1960, pp. 173-182

The use of adhesives and binders containing epoxy resins by California Division of Highways in repairing concrete is described. Illustrations of their use in repair work are given. The discussion includes possible variations in formulation to secure wanted properties for specific uses, methods of application that are necessary to obtain strong and durable repairs, and a typical formulation for general use.

PNEUMATICALLY APPLIED MORTAR FOR RESTORING CONCRETE STRUCTURES.....57-10

O. N. KULBERG—Aug. 1960, pp. 183-192

Pneumatically applied mortar is the most economical and successful means of restoring concrete structures where deterioration is relatively shallow and the restoration areas large and irregular. However, periodic protective applications are necessary in areas of severe exposure to seal hairline shrinkage and temperature cracks that may pass water and perpetuate deterioration of the parent structure.

Large deep deteriorated areas under severe exposure are economically restored by the installation of a metallic membrane.

RESISTANCE TO SHEAR OF REINFORCED CONCRETE BEAMS. PART 1—BEAMS WITHOUT WEB REINFORCEMENT.....57-11

J. TAUB and A. M. NEVILLE—Aug. 1960, pp. 193-220

The redistribution of internal forces in a beam in which the diagonal tension crack has extended to the level of the main tension steel is discussed. It is shown that the resistance to shear of a simply supported beam without web reinforcement depends on the strength of the compression zone at the upper end of the diagonal tension crack and of the tension zone at its lower end. Accepted methods of calculation of shearing stresses give, therefore, an incorrect idea of the strength of the beam, and result in a variable factor of safety.

Different types of shear failure are described, in particular, the shear-tension failure. The influence of various factors on the shear strength of simply supported reinforced concrete beams is described. Results of exploratory tests at the University of Manchester are discussed, with particular reference to the comparison of the strength of rectangular, T-, and L-beams. The behavior of beams loaded through secondary beams is studied on the basis of new tests.

HIGH-STRENGTH DEFORMED STEEL BARS FOR CONCRETE REINFORCEMENT.....57-12

SIDNEY A. GURALNICK—Sept. 1960, pp. 241-282

Results obtained from the testing to destruction of 42 T-beams reinforced with metallurgically-produced high-strength steel deformed bars are presented. Both flexural and shearing failures occurred and the results are compared with the ultimate strength design procedure given in the appendix of the 1956 ACI Building Code and certain other design procedures. Deflections of test beams are compared with values obtained by use of existing methods for computing deflections. Crack data is also reported and evaluated.

EFFECTS OF AGGREGATE SIZE ON PROPERTIES OF CONCRETE.....57-13

STANTON WALKER and DELMAR L. BLOEM—Sept. 1960, pp. 283-298

Research is described supplementing earlier work which indicated a lack of improvement in concrete strength resulting from increased maximum size of aggregate. The more recent program provided a broader range of classes of concrete and test variables for the purpose of checking the degree of applicability of the earlier finding.

The tests were made with maximum sizes of coarse aggregate ranging from 3/8 to 2½ in., using three cement factors, from 4 to 8 sacks per cu yd, both with and without air entrainment. Compressive and flexural strength tests were made at ages of 7, 28, and 91 days, and specimens are available for test at 1 year. Tensile splitting tests were made at 28 and 91 days. Drying shrinkage measurements were also made on all concretes.

Results indicate that increasing the maximum size of coarse aggregate may not necessarily be beneficial to concrete strength. Drying shrinkage was not substantially increased by reduced size of aggregate down to about ¾ in.

TRANSFER OF BENDING MOMENT BETWEEN FLAT PLATE FLOOR AND COLUMN.....57-14

JOSEPH DI STASIO, SR. and M. P. VAN BUREN—Sept. 1960, pp. 299-314

A method is presented for calculating the maximum unit shearing stresses, measuring both diagonal tension and punching shear, due to combined gravity load and bending in flat plate floor slabs about exterior and interior columns. Provision is made for the effect of openings in the column head region. The values of allowable stresses are discussed, and recommendations made for a suggested test program.

RESISTANCE TO SHEAR OF REINFORCED CONCRETE BEAMS. PART 2—BEAMS WITH VERTICAL STIRRUPS.....57-15

J. TAUB and A. M. NEVILLE—Sept. 1960, pp. 315-336

The redistribution of internal forces following the yield of stirrups in a simply supported reinforced concrete beam is described, and it is shown that after the stirrups have yielded the shear strength of a beam depends on the resistance of the compression zone above the diagonal tension crack and the tension zone at the lower end of the crack. Thus the shear strength of a beam is not propor-

tional to the amount of web reinforcement; this is discussed in considerable detail.

The second role of the stirrups in the shear resistance of a beam is their ability to resist the splitting of the beam along the tension steel; for this an effective restraint of the tension steel by the stirrups is essential.

Different types of shear failure are described as well as the influence of various factors on the behavior of reinforced concrete beams failing in shear. Tests at the University of Manchester show the higher strength in shear of T- and L-beams compared with rectangular beams. The influence of cutoff of the tension steel on the shear strength of simply supported beams is described. Suggestions are made on the provision of vertical stirrups in simply supported reinforced concrete beams.

GENERAL FORMULAS FOR MEMBRANE STRESSES IN HYPERBOLIC PARABOLOIDICAL SHELLS.....57-16

FELIX CANDELA—Oct. 1960, pp. 353-372

Complementing a previous paper, a set of general formulas is presented for reinforced hyperbolic paraboloidical shells. These are those giving the membrane stresses in a shell loaded with its own weight but disposed in an arbitrary position in space. The better known formulas for a hyperbolic paraboloidical shell with its z axis vertical can be obtained as a special case of the general formulas. A numerical example of a groined vault on a square plan is also presented.

BUILDING FOR ECONOMY WITH HYPERBOLIC PARABOLOIDS.....57-17

GORDON MADSEN and DUTTON BIGGS—Oct. 1960, 373-384

Designed for multiple use of moving forms, a hyperbolic paraboloid umbrella roof proved extremely economical for a shopping center in Minneapolis. Construction methods are described, as well as structural design features.

HYPERBOLIC PARABOLOIDAL UMBRELLA SHELLS UNDER VERTICAL LOADS.....57-18

HOWARD P. HARRENSTIEN—Oct. 1960, pp. 385-402

Tests were performed on two reinforced concrete hyperbolic paraboloidal umbrella shells. The shells were subjected to a concentrated load at various selected points and resulting strains were observed. Stresses corresponding to these strains were determined, and the results are presented in the form of stress contours for each of nine selected load points. Superposition methods are presented which will predict the final stresses in an appropriate umbrella shell when it is subjected to any vertical loading provided the stresses remain within the proportional limit, and provided that deflections are small.

SHELL AT DENVER—HYPERBOLOIDAL STRUCTURE OF WIDE SPAN.....57-19

ANTON TEDESKO—Oct. 1960, pp. 403-412

A free spanning reinforced concrete shell gives an attractive shape to an exhibit pavilion for a Denver department store. The roof is made of four hyperbolic paraboloidal surfaces and is supported through steel hinges on buttresses in the four corners of a rectangle, 112 x 132 ft; the 3-in. shell rises to a height of 28 ft. This paper describes design and construction features of the structure.

EXPERIMENTS WITH THIN-SHELL STRUCTURAL MODELS.....57-20

J. L. WALING and LONGIN B. GRESZCZUK—Oct. 1960, pp. 413-432

A new method of forming hyperbolic paraboloid concrete shell structures is presented. The method, which depends on the special geometric characteristics of the hyperbolic paraboloid, makes use of wire supported Styrofoam with its high strength to weight ratio as a temporary shell material to support the permanent shell material during curing. The Styrofoam thus serves temporarily as a structural material in lieu of extensive formwork and remains as insulation and vapor barrier throughout the life of the structure.

Experiments which led to the proposed construction procedure made use of space models, table sized construction models, and a laboratory construction model. Results of the model studies indicate possibilities of success with full scale constructions using the proposed materials and construction procedure.

Shells composed of skewed hyperbolic paraboloidal elements to form spherical and barrel type shapes are introduced for further study.

DETERMINATION OF MEMBRANE STRESSES IN ELLIPTIC PARABOLOIDS USING POLYNOMIALS.....57-21

L. FISCHER—Oct. 1960, pp. 433-442

A mathematically simple method for determining the membrane stresses in an elliptic paraboloid is given. The differential equations of equilibrium are solved by the introduction of a polynomial representing the stress function, the coefficients of which are easily determined. The membrane stresses are then readily found as derivatives of the stress function. A numerical example illustrates the use of this method.

RESISTANCE TO SHEAR OF REINFORCED CONCRETE BEAMS. PART 3—BEAMS WITH BENT-UP BARS.....57-22

A. M. NEVILLE and J. TAUB—Oct. 1960, pp. 443-464

The fallacy of the truss analogy in the design of web reinforcement consisting of bent-up bars is discussed. It is shown that after the bent-up bars have yielded, a redistribution of internal forces takes place and the beam can take a considerable increase in load before failure occurs.

The spacing of bent-up bars is discussed, and for full protection from shear failure a limiting value of $2d\,(1 - k)$, measured along the axis of the beam, is suggested. The influence of the cross-sectional area of bent-up bars and the contribution of beam elements to its shear resistance are studied.

From tests on beams subjected to uniformly distributed and nonsymmetrical loads, it is concluded that the provision of bent-up bars in zones of maximum shear only is inadequate. The influence on shear strength of anchorage and cutoff of the tension steel are mentioned.

DESIGN CRITERIA FOR REINFORCED COLUMNS UNDER AXIAL LOAD AND BIAXIAL BENDING.....57-23

BORIS BRESLER—Nov. 1960, pp. 481-490

Several design criteria for columns subjected to compression combined with biaxial bending are discussed. The approximate load carrying capacity is defined in terms of easily determined parameters without the cumbersome trial and error procedures.

CORROSION OF PRESTRESSED WIRE IN CONCRETE.....57-24

G. E. MONFORE and G. J. VERBECK—Nov. 1960, pp. 491-516

After a brief review of the various types of corrosion, the few corrosion failures which have occurred in prestressed wire in concrete are discussed. The failure in the Regina, Sask., Canada, water supply line is examined in detail. A summary of the laboratory investigations of corrosion of prestressed wire in concrete that have been reported in the literature is followed by an account of the studies carried out in the laboratories of the Portland Cement Association. These latter studies included tests of the effects on corrosion of such factors as type of cement, type of wire, wire stress, addition of calcium chloride, curing conditions, storage conditions, and voids in the concrete adjacent to the wires. Many of the tests were evaluated by determination of the reduction in tensile strength of the wires. Field and laboratory observations indicate clearly that calcium chloride in concrete may lead to serious corrosion of prestressing steel. Because of this hazard, it is recommended that calcium chloride not be used in prestressed concrete.

RESISTANCE TO SHEAR OF REINFORCED CONCRETE BEAMS. PART 4—BEHAVIOR OF BEAMS WITH DIFFERENT TYPES OF WEB REINFORCEMENT.....57-25

A. M. NEVILLE and J. TAUB—Nov. 1960, pp. 517-532

A comparison of beams with different types of web reinforcement shows that bars inclined at 45 deg to the axis of the beam are most effective in resisting the diagonal tension stresses. To offer full protection from shear, however, the use of vertical stirrups and bent-up bars combined is preferable. The alternative of orthogonal web reinforcement, consisting of vertical stirrups and horizontal bars at, and possibly also below, the neutral axis, is discussed and experimental data are presented.

MONOLITHIC CAST-IN-PLACE CONCRETE PIPE.....57-26

L. H. KRISTOF—Nov. 1960, pp. 533-548

The development and use of monolithic cast-in-place concrete pipe is discussed, including the merits of this type of water carrying conduit. The various factors that should be considered in evaluating the practicability of the use of this type of conduit are outlined. General summary is made of advantages and limitations of different construction methods.

SIMPLIFYING ULTIMATE FLEXURAL THEORY BY MAXIMIZING THE MOMENT OF THE STRESS BLOCK.....57-27

LYLE E. YOUNG—Nov. 1960, pp. 549-556

A method of simplifying ultimate flexural analysis is described. The stress block is defined by a method of maximizing the moment of the stress block about the neutral axis. Three separate stress functions are used to describe the stress in the concrete. The calculated type of failure and the ultimate moment are compared with results of reinforced concrete beam tests.

REACTIVITY OF ULTRAFINE POWDERS PRODUCED FROM SILICEOUS ROCKS.....57-28

K. M. ALEXANDER—Nov. 1960, pp. 557-570

Siliceous materials such as quartz and basic or devitrified volcanic rocks, which are not likely sources of active pozzolan, become highly reactive when ground to ultrafine powders. If grinding is sufficiently prolonged an upper limit of activity is attained, beyond which continued increase in surface area does not produce any further general increase in pozzolanic reactivity. With widely differing types of siliceous material the upper limit of pozzolanic reactivity attained at very high surface areas tends to be the same in all cases, regardless of whether the mineral powders would be classed as pozzolanic, weakly pozzolanic, or nonpozzolanic when ground to the usual fineness specified for pozzolans. These observations can be explained by the presence of a disturbed layer of highly reactive material which is formed on the surface of siliceous mineral particles as a result of prolonged grinding.

TENTATIVE RECOMMENDATIONS FOR DESIGN OF COMPOSITE BEAMS AND GIRDERS FOR BUILDINGS.....57-29

ACI-ASCE COMMITTEE 333—Dec. 1960, pp. 609-628

ACI-ASCE Committee 333 was organized in 1956 to prepare recommendations for the design and construction of structures composed of prefabricated beams combined with cast-in-place slabs. After a review of the existing information and practices, the committee has channeled one part of its activities toward preparation of recommendations for the design of composite beams and girders for buildings. The results of this work are reported herein. The committee expects to prepare further reports after the completion of research investigations now in progress.

The progress report is written in two parts. Tentative design recommendations are presented in the first part. The second part contains explanations of the provisions of the design recommendations.

CONCRETE AND CONCRETE MATERIALS FOR GLEN CANYON DAM.....57-30

WALTER H. PRICE, L. P. WITTE, and L. C. PORTER—Dec. 1960, pp. 629-648

Considerations involved in the preparation of specifications for aggregates, cement, and pozzolans for Glen Canyon Dam, which will be 710 ft high and contain about 5,000,000 cu yd of concrete, are discussed. Investigations which led to the selection of materials and the decision to remove soft, undesirable particles from the aggregates by heavy media processing are described. The aggregate processing plant, batching and mixing plant, and transportation and handling of the concrete are briefly described.

EFFECT OF DRAPED REINFORCEMENT ON BEHAVIOR OF PRESTRESSED CONCRETE BEAMS.....57-31

JAMES G. MacGREGOR, METE A. SOZEN, and CHESTER P. SIESS—Dec. 1960, pp. 649-678

Tests on 19 simply supported pretensioned concrete beams with draped prestressed reinforcement are described and compared with the results of tests of similar beams with straight prestressed reinforcement. The principal variables included: concrete strength, steel percentage, length of shear span, and the angle and type of drape profile. Web reinforcement was used in only five beams.

In general, it was concluded that draping the longitudinal wires did not increase either the inclined cracking load or the shear strength of the prestressed concrete beams tested. Instead, the trend of the test results indicated a reduction in both the inclined cracking load and the ultimate strength of the beams with draped wires. A comparison of the behavior of beams with draped and straight wires showed that the detrimental effect of the drape on "shear" strength could be ascribed to the earlier formation of flexural cracks in regions of combined bending

and shear and the consequent earlier development of inclined cracks. For extreme combinations of the critical variables, an inclined crack occurred prior to the formation of flexural cracks in its vicinity, in which case draping the wires caused an increase in strength which could be estimated on the basis of an uncracked section analysis.

The beams with draped reinforcement required more web reinforcement to produce a flexural failure than similar beams with straight reinforcement.

STATIC MODULUS OF ELASTICITY OF CONCRETE AS AFFECTED BY DENSITY.....57-32

ADRIAN PAUW—Dec. 1960, pp. 679-688

The elastic modulus of concrete is an important parameter in reinforced concrete design and analysis. With the increased use of lightweight aggregates for structural concrete a better understanding of the relationship between weight, strength, and the elastic modulus is needed. In this study the static modulus for a large variety of aggregates and concrete strengths was analyzed and an empirical formula was derived which is applicable to both lightweight and normal weight structural concretes. The formula is in excellent agreement with recognized empirical formulas for normal weight concrete.

RECONSOLIDATION IMPROVES GROUTED MASONRY WALL PANELS.....57-33

MANLEY W. SAHLBERG—Dec. 1960, pp. 689-696

The type of wall described is actually a reinforced concrete wall cast between bricks or masonry units which act as absorptive forms. It satisfies architects who like brick facings and it also satisfies engineers who want to use these walls to resist lateral forces induced by earthquakes.

The test described was started to demonstrate the practicability of high lift grouting of cavity masonry walls. Some panels were made without vibration, some used vibration or tamping, and others utilized vibration and revibration.

ULTIMATE STRENGTH OF REINFORCED CONCRETE ARCHES.....57-34

O. P. JAIN—Dec. 1960, pp. 697-714

As the load on an arch increases gradually, the portion of the rib near the section of maximum moment starts showing plastic deformations which result in an increase of horizontal thrust in the arch above that given by the elastic theory. This causes a reduction of maximum positive moment and an increase of maximum negative moment and thus the maximum moment in the arch is reduced resulting in a greater load bearing capacity of the arch. It is found that the actual ultimate strength of two-hinged arches of uniform section for various patterns of loading is 50 to 100 percent greater than the ultimate strength given by elastic theory. A method of calculation is presented which takes into account these plastic deformations. Complete agreement is found between the theoretical and test results. Although the calculations refer only to a single concentrated load on the arch, the same approach can be applied to find the ultimate strength for other loading patterns (including dead load).

RESISTANCE TO SHEAR OF REINFORCED CONCRETE BEAMS. PART 5—ANCHORAGE AND BOND.....57-35

J. TAUB and A. M. NEVILLE—Dec. 1960, pp. 715-730

It is shown that hooks at the ends of plain round bars materially increase the load-carrying capacity of a beam failing in shear-tension. Means of lessening the destructive action of hooks are indicated. Beams with deformed bars and vertical stirrups show a considerable resistance to slip, so that composite action in the end parts of the beam is well preserved. This is not necessarily so when no stirrups are present as in some cases the wedging action of the deformations may tend to split the concrete. Bond failure is shown not to be a primary cause of failure but merely a consequence of the redistribution of internal forces following the widening of the diagonal tension crack. For this reason the value of the nominal bond stress at failure depends on the effectiveness of the shear reinforcement of the beam, and the use of a fixed permissible bond stress is shown to result in a greatly varying factor of safety.

ULTIMATE STRENGTH OF NON-RECTANGULAR STRUCTURAL CONCRETE MEMBERS.....57-36

ALAN H. MATTOCK and LADISLAV B. KRIZ—Jan. 1961, pp. 737-766

Test data are presented which demonstrate the applicability to nonrectangular structural concrete members of fundamental plasticity concepts deduced from tests of rectangular structural concrete members.

Flexural tests are reported of symmetrical beams with triangular-shaped concrete compression zones, and of unsymmetric T-beams.

The behavior of the beams tested, and in particular their ultimate strength, is compared with the behavior and ultimate strength predicted by two theories derived from previous tests of rectangular members. One of the two theories considered is of a general nature and is intended primarily for research purposes, the other is based on an equivalent rectangular stress distribution and is suitable for practical design.

INVESTIGATION OF COMPRESSIVE STRENGTH OF MOLDED CYLINDERS AND DRILLED CORES OF CONCRETE.....57-37

BRYANT MATHER and WILLIAM O. TYNES—Jan. 1961, pp. 767-778

This work was done to obtain information on methods being used to estimate the 28-day compressive strength of concrete. Its primary purpose was to determine the relation between the 28-day compressive strength of 6 x 12-in. cylinders molded from samples of concrete mixtures from which aggregate larger than 1½ in. had been removed, and that of 6-, 8-, and 10-in. diameter cores drilled from test structures and containing aggregate graded to 3-in. or 6-in. size. A secondary purpose of the study was to determine the strength relations of 6 x 12-in. concrete cylinders cured in the field and comparable cylinders cured in the laboratory under standard conditions.

The results suggest that estimates of the 28-day compressive strength of concrete containing 3- or 6-in. aggregate will not be significantly different whether based on results of compressive strength tests of similarly cured 6 x 12-in. cylinders of the same concrete wet-screened over a 1½-in. sieve, or on results of tests of 6-, 8-, or 10-in. diameter cores drilled from the structure and having a height equal to twice the diameter. The results suggest, however, that the smaller the core diameter, the larger the number of test cores should be to yield results of a given precision. It is indicated that cores should be more than 11 in. in diameter to give as precise an estimate of strength as that given by an equal number of 6 x 12-in. cylinders. As has been indicated by many previous studies, comparison of the field-cured and standard-cured cylinders showed that concrete cured at lower temperatures has a lower compressive strength than concrete cured under standard conditions.

FREEZING AND THAWING TESTS OF LIGHTWEIGHT AGGREGATE CONCRETE.....57-38

PAUL KLIEGER and J. A. HANSON—Jan. 1961, pp. 779-796

Nine lightweight aggregates and one natural sand and gravel aggregate were used in concretes subjected to laboratory freezing and thawing tests and, in some cases, to tests for resistance to deicer scaling. Concretes were prepared at two levels of compressive strength: 3000 psi and 4500 psi at 28 days. Both non-air-entrained and air-entrained concretes were prepared, using the aggregates in an air-dried condition and in a 24-hr saturated condition.

The results of these tests indicate the necessity for providing intentionally entrained air to attain a high level of durability, the importance of moisture content of aggregate, and the influence of strength level, i.e., water-cement ratio, on the durability. The results point to the desirability of evaluating a lightweight aggregate by means of laboratory freezing and thawing tests of air-entrained concrete made with the aggregate, as is generally done for normal weight aggregate.

11-YEAR STUDY OF CONCRETE STAVE SILO DURABILITY.....57-39

RESEARCH SUBCOMMITTEE, ACI COMMITTEE 714—Jan. 1961, pp. 797-812

In 1940, ACI Committee 714 set up a research program to test the adequacy of a proposed ACI standard, "Recommended Practice for the Construction of Concrete Farm Silos." The test consisted of four silos erected on the Ohio Agricultural Experiment Station at Wooster, Ohio. Each of the silos contained dry-tamped and wet-cast staves made from concrete mixes containing three grades of aggregate, three levels of cement content, and two types of cement. In addition to these variables, the interiors of two of the silos were coated with a portland cement "wash-coat" while the other two were left uncoated. The silos were used for storing silage under conditions similar to those found in average farm service.

Periodic visual observations of the conditions of the staves were made during the 11-year test period. Flexural strength and absorption tests of the staves, performed on unexposed staves near the start of the project and also on 11-year old staves removed from the silos, showed good correlation with the visual results. The study showed that to obtain the desired low absorption and high strength values, silo staves must be made from concrete containing good aggregate and moderately high cement content. Proper application of a portland cement wash coat will substantially increase the service life of a quality concrete stave silo.

The tests specified for concrete staves in ACI 714-46 are good yardsticks for measuring the durability of concrete silos in service; however, results of this study indicate that a more restrictive current standard would result in prolonged life of the staves under service conditions.

GRAVEL BENEFICIATION IN MICHIGAN.....57-40

FRANK E. LEGG, JR. and WILLIAM W. McLAUGHLIN—Jan. 1961, pp. 813-826

Michigan natural gravel is now competing with imported high quality coarse aggregates intended for concrete subject to severe winter exposure, as a result of installation of various types of beneficiation plants. Thus, local deposits are being utilized, after upgrading, without sacrifice of concrete quality. This development was prompted in large measure by the decision of the Michigan State Highway Department that aggregate quality standards would not be relaxed despite the greatly increased demand of the accelerated highway construction program.

Many of Michigan's lower peninsula glacial gravels have been found particularly amenable to upgrading by heavy media separation, although commercial installations of elastic fractionation, jigs, and soft particle disintegrators are being tried. At present, 14 beneficiation plants are operating in the state. Laboratory concrete freeze-thaw evaluations of the effectiveness of several of the plants are presented together with observations on routine field inspection. Caution is advised against undue optimism of one beneficiation process as opposed to another for all deposits—tailoring of the particular process to the needs of each aggregate source, together with consideration of economics involved, seems the wiser course of action.

THE STRUCTURAL MEMBRANE.....57-41

KOLBJORN SAETHER—Jan. 1961, pp. 827-850

Even though ideal from a structural point of view, elastic membranes have been almost excluded from the structural field due to the complexity of mathematical work involved. Structural membranes, however, which are close to identical in appearance and structural behavior, permit the use of only elementary mathematics for defining the shape and analyzing the stresses within its surface. The basic theory of funicular shapes and the transformation of these into structural membranes is shown.

Savings on materials typical for all thin shell structures, together with ease of design and construction, are some of the advantages promised by structural membranes.

PRECAST GRID-WALL FOR BANQUE LAMBERT.....57-42

MATTHYS P. LEVY—Feb. 1961, pp. 865-874

A discussion of the design and construction procedure for a grid-wall consisting of closely spaced precast concrete columns. The merit of placing a hinge at midheight between floors is compared to the difficulties encountered in making a moment connection at the floor level. Examples are given of the present trend in the design of grid-walls. The cost of a grid-wall is compared to the cost of a conventional curtain wall with separate structural columns, and factors affecting cost are evaluated.

RECTANGULAR CONCRETE STRESS DISTRIBUTION IN ULTIMATE STRENGTH DESIGN.....57-43

ALAN H. MATTOCK, LADISLAV B. KRIZ, and EIVIND HOGNESTAD—Feb. 1961, pp. 875-928

An ultimate strength design theory of broad applicability is developed, based on an equivalent rectangular stress distribution in the concrete compression zone and in general accord with the Appendix to the 1956 ACI Building Code. The theory is characterized by simplicity without significant loss of accuracy.

The proposed method of ultimate strength design is applied to a wide variety of structural concrete beams and columns, subject to various combinations of bending and axial load. Calculated ultimate strengths are compared with experimentally determined ultimate strengths for a wide range of variables, and an excellent agreement results.

It is concluded that the proposed extension of the rectangular stress distribution theory permits prediction with sufficient accuracy of the ultimate strength in bending and compression of all types of structural concrete sections likely to be encountered in structural design practice, including odd-shaped sections and other unusual cases.

CREEP OF PRESTRESSED CONCRETE BEAMS.....57-44

W. S. COTTINGHAM, P. G. FLUCK, and G. W. WASHA—Feb. 1961, pp. 929-936

Presents test results obtained during 7 years of sustained loading of six prestressed concrete beams. Each beam was end-supported over a 20-ft span and uniformly loaded.

Two beams were loaded to full design load, two were loaded to ¾ design load, and two were loaded to ½ design load. Creep deflections and creep strains measured during the 7 year loading period are reported. Deflection and strain recoveries due to removal of the loads and for 64 days after load removal as well as the final failure loads for the beams are reported.

PRESTRESSED PRECAST ARCHES FOR INDUSTRIAL ROOF.....57-45

E. R. CANCIO and A. HERRERA—Feb. 1961, pp. 937-946

Describes the structural design of an industrial building in Havana, Cuba, to meet special requirements. Several solutions were considered but the one selected consisted of prestressed joists and tied arches having spans up to 102 ft 6 in. Prefabrication was used to a large extent. Unit costs are also given.

RHEOLOGICAL BEHAVIOR OF HARDENED CEMENT PASTE UNDER LOW STRESSES.....57-46

JOSEPH GLUCKLICH and ORI ISHAI—Feb. 1961, pp. 947-964

Rheological experiments determined the complete rheological model of hardened cement paste. It is shown that for a W/C ratio of 0.32 and air-sealed material the model consists of: (a) a Hookean spring; (b) three Kelvin elements, of different parameters, in series; (c) a nonreversible Kelvin element; (d) an element comprising a dashpot, representing deformation due to microcracking. All these elements are connected in series. Elements (a) and (b) represent reversible deformation, while (c) represents a nonreversible deformation and (d) a small deformation reversible up to a few hours after loading and nonreversible thereafter. It is suggested that the deformational response of the material to load is dependent on hygrometric conditions to such a degree as to make the resulting quantitative differences seem like differences of quality. The various rheological parameters were determined.

ULTIMATE STRENGTH OF A FOLDED PLATE STRUCTURE.....57-47

GREGORY P. CHACOS and JOHN B. SCALZI—Feb. 1961, pp. 965-972

Objectives of this investigation were to determine the behavior of the folded plate structure as a simple beam with an irregular cross section and to verify the ultimate moment capacity by the rectangular stress block method. For this type of structure the ultimate collapse load agreed with the theoretical load within 1.8 percent.

FORMWORK FOR CONCRETE.....57-48

ACI COMMITTEE 622—Mar. 1961, pp. 993-1040

Part 1 of this report discusses present practice, formwork problems, and the need for improved formwork practice to promote safety, uniformity, and economy in this important phase of concrete construction; Part 2 is a general discussion of responsibility of the engineer or architect and what information (other than that covered by Part 3) should be provided in his plans and specifications; and Part 3 consists of suggested requirements for formwork practice.

In Part 3 Chapters 1, 2, and 3 cover general provisions, minimum design requirements, loads and allowable unit stresses, construction requirements, and form materials applicable to formwork for the great majority of projects involving concrete; Chapters 4 and 5 deal with special concrete structures and special methods of construction. It is believed these suggested formwork practices will be found helpful and suitable for a wide variety of concrete structures.

WORK OF THE EUROPEAN CONCRETE COMMITTEE.....57-49

FRANCO LEVI—Mar. 1961, pp. 1041-1070

Summarizes recommendations approved by the Comite Europeen du Beton (CEB) since its organization in 1953. Among the recommendations reviewed are those on ultimate strength design, T-beams, buckling, cracking, deformation, shearing stress, safety factors, and notation. A brief account of planned activities of CEB is also presented.

INVESTIGATION OF BOND IN BEAM AND PULL-OUT SPECIMENS WITH HIGH-YIELD-STRENGTH DEFORMED BARS.....57-50

ROBERT G. MATHEY and DAVID WATSTEIN—Mar. 1961, pp. 1071-1090

Bond strengths were determined in 18 beam and 18 pull-out specimens with deformed reinforcing bars having a nominal yield strength of 100,000 psi. The lengths of embedment ranged from 7 to 17 in. for #4 bars and from 7 to 34 in. for #8 bars. The bond strength was found to decrease with increases in the length of embedment for a bar of a given size. The bond also decreased with an increase in the bar diameter for a given length-diameter ratio. Bond failures were obtained in all beams containing #8 bars; with #4 bars, both tensile and bond failures were observed.

The ultimate bond stresses in the pull-out specimens agreed in general with the values obtained in beams with #4 bars. However, for #8 bars the bond strengths in pull-outs were significantly greater than the values obtained with beams.

It was found advisable to use either a loaded-end slip of 0.01 in. or a free-end slip of 0.002 in. to define "critical" bond stresses, depending on which of these slips developed first. Bond stresses corresponding to these values of slip were sufficiently low to insure that under-reinforced beams designed on the basis of these criteria would fail by yielding of reinforcement.

A CASE OF ABNORMALLY SLOW HARDENING CONCRETE FOR TUNNEL LINING.....57-51

LEWIS H. TUTHILL, ROBERT F. ADAMS, SHELLY N. BAILEY, and RONALD W. SMITH—Mar. 1961, pp. 1091-1110

When job concrete does not set for several days there is usually a reason. When the correct reason is not found, the blame may fall where it is undeserved but worse still, nothing is learned to prevent a recurrence. This paper describes such an experience and the related testing which shows that one cause of belated hardening, when a lignin-base water-reducing admixture is used, is too little SO_3 in the cement.

STRUCTURAL MODELS EVALUATE BEHAVIOR OF CONCRETE DAMS.....57-52

JEROME M. RAPHAEL—Mar. 1961, pp. 1111-1128

An unusual arch and buttress dam was proposed as one possible design for the 750 x 5000 ft Oroville Dam. A plaster-celite, 1:200-scale model was cast in Fiberglas molds to duplicate the central portion of the dam. Live load tests were performed on the dam, simulating the uniformly increasing water pressure by a series of rubber bags under stepped pneumatic pressure. The control apparatus is described, and the results of the water load tests are given. A new method of dead load testing was

devised by which the construction stresses as well as the dead load stresses of the completed dam could be determined. Dead load stresses are shown for various stages of construction, as well as the stresses under combined live and dead loads. The technique for dead load testing offers opportunity for checking the stresses in concrete dams under various proposed construction programs and should be especially useful for controlling the construction of the overhanging portions of doubly-curved arch dams.

ULTIMATE STRENGTH OF SQUARE COLUMNS UNDER BIAXIALLY ECCENTRIC LOADS.....57-53

RICHARD W. FURLONG—Mar. 1961, pp. 1129-1140

The ultimate strength capacity of square columns under biaxially eccentric loads is investigated using Whitney's equivalent rectangular stress distribution. A description of ultimate strength behavior is presented in the form of column interaction diagrams at various skew angles of eccentricity.

LOAD TESTS OF PATTERNED CONCRETE MASONRY WALLS.....57-54

R. O. HEDSTROM—Apr. 1961, pp. 1265-1286

Laboratory tests were performed to determine compressive and flexural strengths of concrete block walls laid in nine different patterns. Flexural tests were made on wall panels subjected to bending across a vertical and a horizontal span. Two types of mortar were used. Reinforcing steel was included in some of the walls tested in flexure across a horizontal span. The performance of the walls laid in the various patterns is compared to that of standard running bond.

WATER-CEMENT RATIO VERSUS STRENGTH—ANOTHER LOOK.....57-55

HERBERT J. GILKEY—Apr. 1961, pp. 1287-1312

The water-cement ratio (W/C) pronouncement probably marked the most useful and significant advance in the history of concrete technology.

From the beginning, however, there have been dissenters who in their tests or research have happened to touch areas of unusual gradings or areas that entailed comparisons between mortars and concretes or between neat cement pastes and sand-cement mortars.

Besides the actual dissenters there have been thoughtful operators in the area of large-aggregate concrete, used regularly in dams, who, recognizing the lack of information on possible effects of large aggregates and/or large specimens on strength have serious doubts as to whether or not the mass concrete in the structure would develop the strength that the W/C relationship has allocated to it.

With current attention being redirected toward possible limitations in the W/C generalization, now may be the time to exhume and pull together scattered pertinent evidence that has, bit-by-bit over the years been presented, and forthwith become buried in the voluminous literature of concrete. The aim is not to discredit the water-cement ratio as a useful empiricism but rather to focus attention on both its range of applicability and on its limitations.

The paper calls attention to, and discusses briefly, a number of the published allegations of invalidity, indicating some of the pros and cons brought out in discussions thereof. As support for tentative explanations, pertinent stress-strain and water-gain data are presented. Finally a modified, duly restricted and qualified version of a W/C versus strength relationship is proposed.

PRECAST AND PRESTRESSED FOLDED PLATE SLABS.....57-56

HARRY H. EDWARDS—Apr. 1961, pp. 1313-1322

Prestressed precast folded plate concrete slabs offer tremendous potential for widespread use in buildings for roof, floor, and wall construction and in highway bridges.

A relatively low capital investment in prestressing facilities will produce a complete span range of folded plate products limited only by the ability to deliver and erect. The cost of folded plate structures promises to be competitive with other building materials for long spans and heavy loads.

Prestressed folded plate offers the opportunity of bringing the advantages of concrete construction—strength, fire resistance, blast resistance, and low maintenance cost—into buildings of all price ranges, and in addition, makes it economically feasible to design concrete structures in the 50- to 120-ft span range.

LOAD-DEFLECTION AND VIBRATION CHARACTERISTICS OF A MULTISTORY PRECAST CONCRETE BUILDING.....57-57

JACK R. JANNEY and JOHN F. WISS—Apr. 1961, pp. 1323-1336

The load-deflection and vibration characteristics of a structure are closely associated. The use of high strength concrete in prestressed building elements along with composite construction can produce building components which have resonant frequencies at various stages of loading to which the human body is sensitive. Vibrations with low amplitude may be sensed easily if the resonant frequency of the structure is relatively high. This paper describes full scale load and vibration tests conducted on a multistory precast building. The degree of composite action was determined and found to be much more complete than normally considered in design. The vibration characteristics were determined and are discussed.

TORSIONAL STRENGTH OF PRESTRESSED CONCRETE MEMBERS.....57-58

PAUL ZIA—Apr. 1961, pp. 1337-1360

Reported are the results of torsional tests of 68 pretensioned and plain concrete members consisting of rectangular, T- and I-sections. Some of the specimens also contained web reinforcement in the form of ties.

For the rectangular and T-sections, the test results compare closely with the predicted strength by a modification of Cowan's failure criterion. According to this criterion, which is noted as a close approximation of Mohr's failure theory, the optimum uniform prestress is 70 percent of the concrete cylinder strength. Corresponding to this optimum value, the torsional strength of a member is increased to 281 percent of that of the similar plain concrete member if the cylinder strength is 6000 psi.

For the I-sections, the test results exceed considerably the predicted strength. Explanation of this discrepancy is offered as being the consequence of stress redistribution after the initial cracking. However, it is suggested that the usable strength of such a section be taken as the cracking moment, since the cracks due to torsion remain open on unloading and thus permanently damage the concrete member.

SHELL CONSTRUCTION—A NEW APPROACH.....57-59

WALTER E. RILEY—Apr. 1961, pp. 1361-1372

To reduce cost of forming thin shell concrete roofs, an economical method of construction is desired. The design, construction, and load testing of a 15 x 30 ft cylindrical test shell using a new approach is described.

FIXED-END MOMENTS IN COLUMNS OF ASYMMETRICAL MULTISPAN INTEGRAL FRAMES DUE TO LONGITUDINAL DISPLACEMENTS.....57-60

SHU-T'IEN LI—Apr. 1961, pp. 1373-1386

Presents a general method for determining fixed-end moments in columns due to thermal changes, shrinkage, and rib-shortening of the monolithically continuous girder in asymmetrical integral bridge frames having different span lengths, column heights, and moments of inertia either constant or variable, and hence it is applicable to any combination of them in any form.

UNIVERSAL MATERIAL—COSMOPOLITAN SOCIETY.....57-61

JOE W. KELLY—May 1961, pp. 1409-1416

Joe W. Kelly, professor of civil engineering, University of California, Berkeley—retiring president of ACI—discusses the uniqueness of concrete pointing out that the best years of this most widely used material are still ahead, but if we are to advance successfully we will need both domestic and international cooperation.

FIRE RESISTANCE OF PRESTRESSED CONCRETE BEAMS.....57-62

L. A. ASHTON and S. C. C. BATE—May 1961, 1417-1440

Presents the results of an investigation of the fire resistance of prestressed concrete beams with post-tensioned cables, which was carried out by the Joint Fire Research Organization, Boreham Wood Hertfordshire, England, with the cooperation of the Building Research Station.

The main object of the investigation was to obtain information on the design of beams for buildings of high fire risk, such as large warehouses, where a fire resistance of 4 hr would be required for structural elements.

It is shown that, for normal forms of composite prestressed concrete given to the prestressing steel. For hard-drawn steel wire, a cover to the beams used in Poor construction, resistance is governed by the protection cable of 1½ in. of concrete is sufficient to give a fire resistance of 1 hr; for longer periods of fire resistance, secondary reinforcement is necessary to hold the concrete cover in place, and a cover of 4 in. gives a fire resistance of 4 hr. By further increasing the concrete cover, fire resistance of up to 6 hr may be obtained.

The results of subsidiary tests to determine the effects of load, end-restraint, additional insulation and form of section are presented and discussed, and the effects of partial damage in fire are also considered.

CONCRETE FOR THE MAMMOTH POOL POWER TUNNEL.....57-63

NEVILLE S. LONG and THOMAS W. HOWELL—May 1961, pp. 1441-1458

Construction of the Mammoth Pool Power Tunnel provided an excellent opportunity for obtaining concrete at a minimum cost with maximum use of local materials.

The combination of an owner operated aggregate plant and a cooperative contractor made possible the achievement of minimum cost concrete. Satisfactory 2000 psi concrete in the tunnel invert was produced from crushed aggregate using as little as 325 lb of cement per cu yd.

PRESTRESSED CONCRETE BEAMS BY ELECTRONIC COMPUTER.....57-64

CHARLES WILSON—May 1961, pp. 1459-1474

Describes the analysis and design of prestressed concrete bridge members as performed by a small-scale electronic computer. Specifically, the member must be a simply supported longitudinal highway bridge beam carrying standard AASHO trucks. To demonstrate results of programing, an illustrative problem is presented showing input data, computational effort, and computer results.

RESPONSE OF CONCRETE SHEAR KEYS TO DYNAMIC LOADING.....57-65

ROBERT J. HANSEN, EDWARD G. NAWY, and JAYANT M. SHAH—May 1961, pp. 1475-1490

A series of comparative static and dynamic tests on three types of concrete shear keys has been completed. Results indicate that plain concrete shear keys can withstand stresses as high as 2000 psi, that imposing transverse compression on the keys raises the ratio of shear to compressive strength by about 50 percent in the dynamic loading case though by only about 5 percent in the static loading case, and that keys indicate much higher shear strengths when loaded dynamically than statically.

CONCRETE PROPERTIES RELEVANT TO REACTOR SHIELD BEHAVIOR.....57-66

C. P. THORNE—May 1961, pp. 1491-1508

Available information on the factors affecting the properties of concrete relevant to the determination of the stresses in a concrete reactor shield is examined in detail, and the need for further investigation of several of these properties is noted. As a result of this examination it is possible to state the type of concrete best suited to the particular requirements of reactor shielding. The effect of partial drying of the shield on the distribution of temperature and unrestrained strain is examined theoretically and it is shown that the distribution of moisture content in the shield is of major importance.

"LIFTING" HURON TOWERS.....57-67

PHILIP N. YOUTZ—June 1961, pp. 1537-1548

Describes the architectural design and construction of the 12-story Huron Towers in Ann Arbor, Mich. This two-tower apartment building was designed for lift slab construction. Foundation design, slab design, and lift operations are described along with the architectural features.

CAMBER IN PRESTRESSED CONCRETE BEAMS.....57-68

D. E. BRANSON and A. M. OZELL—June 1961, pp. 1549-1574

Investigation examined experimentally the initial-plus-time-dependent camber deformation in both noncomposite and composite prestressed concrete beams. Methods for calculating these deformations relative to certain properties of the concrete are presented. Ten noncomposite beams and five composite beams were used in the tests. Total camber deformation was found to follow closely the prestress level (relative to concrete strength) but to be relatively insensitive to different concrete strengths and atmospheric conditions. Total camber appears to reach its ultimate value relatively early (100 to 200 days for the test beams) compared to the long-time

shrinkage and creep strains that occur. The analytical methods set forth for predicting camber deformation in both noncomposite and composite beams were found to be in good agreement with the test results. The necessary concrete coefficients for the analysis of total camber were experimentally determined and are presented here and recommended for design purposes.

DURABILITY OF CONCRETE IN SEA WATER.....57-69

INGE LYSE—June 1961, pp. 1575-1584

Paper deals with the durability of concrete when exposed to freezing and thawing in sea water. Extensive experimental investigations have for the past 20 years been carried out at the concrete laboratory of Norway's Institute of Technology, Trondheim, and the most important results from these investigations are reported here.

Among the more important results is that freezing and thawing in sea water is much more detrimental to the durability of the concrete than is the freezing and thawing in fresh water. Furthermore, it is shown that the amount of entrained air necessary for giving the highest resistance of the concrete to frost action in sea water is in the range of 10 to 12 percent, which is more than twice as large as for concrete in fresh water.

V.58 SYNOPSES

Institute papers and reports of Proceedings V. 58

(July 1961-December 1961 ACI JOURNAL)

J. A. HANSON—July 1961, pp. 1-40

Describes the tests employed and the results obtained in an extension of a previous study of diagonal tension resistance reported by the author. This extension of the original program involves lightweight concrete beams of longer span and lower steel percentages. An important conclusion, that diagonal cracking load should be considered as the ultimate load for non-web-reinforced beams, has been confirmed.

A large number of 6 x 12-in. cylinders from the beam concretes were broken by the "split-cylinder" tension test. Good correlation was established between this indirect tension measurement and the shear resistance of the beams at diagonal cracking. This correlation shows that the diagonal tension resistance of lightweight concrete varies from approximately 60 percent of that of the similar normal weight concrete to nearly 100 percent, depending on the particular lightweight aggregates used.

Proposed ultimate load design recommendations are made for structural lightweight concrete. These are in general accord with the recommendations of the ACI-ASCE Committee 326 on shear and diagonal tension for normal weight concrete. It has been found that diagonal tension strength of the lightweight concretes is affected by the same variables as affect the resistance of normal weight concrete. The difference between the two types of materials is one of magnitude of diagonal tension resistance and not of fundamental difference in behavior.

The proposed design recommendations also provide for the fundamental differences in tensile resistance that exist between the various lightweight aggregates. A combination of compressive strength and split-cylinder tension testing provides a convenient and safe measure of the ultimate diagonal tension resistance to be associated with each of the various aggregates.

ARTHUR R. ANDERSON and A. T. WAIDELICH—July 1961, pp. 41-58

Describes the salient design and construction features of a two-story precast and prestressed concrete building at the Developmental Center of the Boeing Airplane Co., Seattle, Wash. The floor area was more than 500,000 sq ft, which was cast, erected, and completed in about 14 months. The story heights are 25 ft each. The column spacing is 60 x 40 ft on the second story and 30 x 40 ft on the first floor, so that the column lengths are alternately 50 and 25 ft.

Details and construction procedures were used which developed full continuity at all joints of the precast members and also achieved load-carrying participation of the roof deck and second floor slab.

The majority of the precast and prestressed members were fabricated on the site, including end-supported prestressed lightweight concrete wall panels as high as 20 ft and spanning a maximum of 40 ft.

ALEXANDER KLEIN, TSEVI KARBY, and MILOS POLIVKA—July 1961, pp. 59-82

Expansion characteristics and compressive strengths were determined for concretes containing expansive cement to evaluate the factors relating to control of the expansive reaction. The expansive cement consists of a portland cement component and a calcium-sulfoaluminate anhydrite component. The factors influencing the magnitude and rate of the expansive reaction include: chemical composition of the components, fineness of the sulfoaluminate component, proportions of the two components in the total cementing material, ratio of water to total cementing material, richness of mix, conditions of curing, and degree of restraint.

In this investigation, the chemical composition of the components and the fineness of the sulfoaluminate component were kept essentially constant, and other factors influencing magnitude and rate of expansion were varied.

For this study, restraint in all cases was provided by external steel mechanisms, in some cases restraint being uniaxial, and in other cases biaxial. In the absence of restraint, concretes exhibited free expansions up to 6 percent or more.

The properties of the concretes reported herein indicate that certain of the expansive cements tested are suitable for structural work and can effectively be employed in the manufacture of chemically prestressed members under conditions of external restraint. It was established that with proper mix proportioning and curing, with compositions, proportions, and fineness of components fixed, it is possible to produce concretes having desired predetermined characteristics within a practical range.

A. L. PARME and H. W. CONNER—July 1961, pp. 83-106

To increase confidence in the use of the beam method for the analysis of interior cylindrical shells and also provide data for those cases in which the beam method is not applicable, design constants for interior cylindrical shells based on the shell theory are presented. These constants enable the ready evaluation of the internal forces in shells by a few simple multiplications. In addition studies on the effect of the geometry of the shell on the longitudinal distribution of stresses are included. A discussion of the effect of continuity enlarges the applicability of the design constants.

RICHARD R. BRADSHAW, Aug. 1961, pp. 129-148

General differential equations of a shell are presented with a method of solution for same. The bending and twisting moment terms are included. The boundary conditions are considered in the solution. The shell has no ribs or hinges. Also, a more rational approach to buckling of concrete shells is presented with consideration being given to large deflection theory of buckling and plasticity effects. The construction and behavior of the shell are discussed.

WARREN H. GRAY, JOHN F. McLAUGHLIN, and JOHN D. ANTRIM—Aug. 1961, pp. 149-162

Fatigue tests were conducted on two different lightweight aggregate concretes, one proportioned for a high strength and the other for a low strength. Specimens of approximately the same age were tested at stress levels of

40, 50, 60, 70, and 80 percent of the ultimate static compressive strength of the respective mixes. Within the limits of the investigation, the fatigue behavior of high strength lightweight concrete was similar to that of low strength lightweight concrete. In addition, the fatigue behavior of the lightweight aggregate concrete appears to be similar to that found for a normal weight concrete in a previous study.

COMPARISON OF FOUR DIFFERENT METHODS OF DETERMINING DRYING SHRINKAGE OF CONCRETE MASONRY UNITS **58-7**

J. O. BRYSON and D. WATSTEIN—Aug. 1961, pp. 163-184

Four different procedures for determining the drying shrinkage of concrete masonry units were compared to determine their suitability as possible standard test methods. The test procedures differed mainly by the conditions under which the specimens were dried and were designated RT-50 (73 F and 50 percent relative humidity), RT-30 (73 F and 30 percent relative humidity), Modified British (122 F and 17 percent relative humidity), and Rapid (220-235 F). In addition to varying the drying conditions, the size and shape of test specimens were also varied. The drying-shrinkage test was performed using all four procedures on both autoclaved and low-pressure steam cured block of sand and gravel, cinders, expanded slag, expanded shale, and pumice aggregates.

SUPPORTING STRUCTURE FOR RETRACTABLE ROOF OF THE PITTSBURGH PUBLIC AUDITORIUM **58-8**

EDWARD COHEN and H. REY HELVENSTON—Aug. 1961, pp. 185-202

Paper describes concrete supporting structure, design conditions, construction of the ring girder and podium, foundation, abutments and anchorages, and the concrete requirements. Unique feature of the auditorium is its vast retractable roof which is mounted on a circular reinforced concrete ring girder 34 ft above the arena floor. All concrete has been placed and the Auditorium is scheduled for completion late in September 1961.

CHARACTERISTICS OF SORPTION AND EXPANSION ISOTHERMS OF REACTIVE LIMESTONE AGGREGATES **58-9**

R. F. FELDMAN and P. J. SEREDA—Aug. 1961, pp. 203-214

Characteristic differences have been detected in the sorption and expansion isotherms of alkali-treated and untreated reactive limestone aggregate; these results are compared with those obtained from Vycor glass under similar conditions. It is concluded that the evidence establishes the presence, within the pores of the aggregate, of trace amounts of a material that causes expansion when water is made available to it and that the mechanism of expansion is similar to the alkali-silica complex formed in the pores of Vycor glass although the composition of the materials in the two cases may be different.

PLASTIC STRAIN IN PRESTRESSED CONCRETE BEAMS UNDER SUSTAINED LOAD **58-10**

JOHN N. CERNICA and M. JEAN CHARIGNON—Aug. 1961, pp. 215-222

Fourteen concrete beams were loaded under sustained load at the third-points for 1 year. The beams were identical except for the type of coarse aggregate. All 14 were loaded with a load equal to 45 percent of the average ultimate of six beams tested under short-time static load. Strain was measured at the center of the beam (a section of pure bending) at four different depths of the beam, viz., top, upper third, lower third, and bottom. The results show that under sustained loading the time-rate of plastic compressive strain in the concrete is initially rapid and then gradually decreases in both the slag and limestone beams. Furthermore, at the end of 1 year, the plastic compressive strain was a little over twice the elastic strain as measured by SR-4 strain gages.

TESTS OF RIGID FRAME BRIDGE MODEL TO ULTIMATE LOAD **58-11**

D. H. PLETTA, ARPAD A. PAP, and CHING-SHENG WU—Aug. 1961, pp. 223-242

A one-tenth scale model of an existing skewed reinforced concrete rigid frame bridge was constructed and tested both within the elastic range and up to initial cracking in the concrete and then to ultimate load. The model was fabricated of reinforced concrete using ⅛ in. deformed reinforcing. A total of 57 SR-4 rosette gages were used to measure strains on the surface of the concrete at selected positions. Additional 108 SR-4 gages were fastened to the steel reinforcing. Deflections were measured at 11 points of the deck, and horizontal reactions determined by suitable dynamometers.

Part of the strain data was converted to unit stress for several loadings. Concentrated loadings located at or near the center of the deck produced large local strains, especially in tension. The model was essentially elastic up to about one-third ultimate load and failed in the abutment at the knee.

MASONIC HOME AND SCHOOL CHAPEL IN FORT WORTH, TEXAS **58-12**

FRANK W. CHAPPELL—Sept. 1961, pp. 273-280

Two items of interest to designers in concrete are incorporated in the chapel of the Masonic Home and School in Ft. Worth, Tex. In order of construction they are: (a) Foundation design to protect a monumental structure from damage by a highly expansive soil which has wrecked one large building nearby and has badly cracked several others and (b) a structural frame of precast concrete members having a decorative finish, and requiring concealed connections.

EFFECT OF STEAM CURING ON THE IMPORTANT PROPERTIES OF CONCRETE **58-13**

ELMO C. HIGGINSON—Sept. 1961, pp. 281-298

Because steam curing of concrete is widely used in the manufacture of precast concrete products, especially concrete pipe, investigations were conducted in the Bureau of Reclamation laboratories to determine the effect of steam temperatures from 100 to 160 F, length of steam curing from 6 to 48 hr, and of a 1- and 3-hr delay prior to steaming, on the important properties of concrete. Properties of the concrete which were studied include compressive strength, modulus of elasticity, durability as measured by the freezing and thawing test, permeability, volume change, resistance to abrasion, and resistance to sulfate attack. Research was also conducted to determine steam curing effect on drying shrinkage, dynamic modulus, weight change to 6 months' age, and modulus of rupture.

In general, concrete that has been steam cured and then air dried is not as good as concrete that has been continuously fog cured or even fog cured for 7 days. Supplemental fog curing after the steam cure period improves the quality of the steam-cured concrete. However, concrete of high quality can be produced using steam curing properly applied.

CONCRETE SHEAR WALLS COMBINED WITH RIGID FRAMES IN MULTISTORY BUILDINGS SUBJECT TO LATERAL LOADS 58-14

BERNHARD CARDAN—Sept. 1961, pp. 299-316

In many multistory concrete buildings where shear walls are used, the lateral loads are resisted partially by the walls and partially by a system of rigid frames. If a few simple assumptions are made with regard to the properties of the building, it is possible to express the angle deflection of the wall at all points with a second degree differential equation, taking into account the effect of bending and shear.

For a number of common loading conditions this equation is solved, and formulas for all moments and shears in walls and frames given, ready for immediate and practical use.

First, the assumption is made that the shear walls are fixed at their bases; but it is later shown how elastic supports or hinged bases can be considered.

LATERAL STABILITY OF A PRESTRESSED CONCRETE GIRDER 58-15

WALTER PODOLNY, JR. and JOHN B. SCALZI—Sept. 1961, pp. 317-326

The object of this research was to apply theoretical lateral buckling relationships to a prestressed concrete girder to determine the validity of the theory and the limitations of the assumptions.

Based on theoretically established proportions, a test girder was constructed 43 ft 6 in. long, with an inverted T cross section. The girder was loaded uniformly along the bottom flange, leaving the top compression flange unsupported for its entire length. Lateral buckling was found to be of little or no consequence in this test where, in accordance with present code restrictions, at least three lateral braces would have been necessary. Several theories indicated that the ultimate capacity of the concrete would be approached or exceeded before lateral buckling would occur.

The various theories predicting the elastic lateral buckling of the beam based on varying degrees of restraint of the bottom flange indicate that the roof deck does provide restraint to the tension flange.

A complete evaluation is difficult to make when based on the behavior of only one beam test. However, the test indicates that it is conservative to assume the beam to behave as a flat plate unrestrained along the tension flange.

As a further conclusion the test indicates that perhaps the current lateral buckling restrictions of the present codes should be re-examined to determine a more realistic requirement.

THERMAL AND SHRINKAGE STRESSES IN COMPOSITE BEAMS 58-16

WILLIAM ZUK—Sept. 1961, pp. 327-340

Equations are developed for both longitudinal and transverse stresses in composite beams under various conditions of temperature and shrinkage. Equations for the interface shears and moments between the slab and the beam are also presented to show the order of magnitude of such induced stresses. The induced stresses and deflections in themselves often exceed the values permitted by standard specifications.

SLABLESS TREAD-RISER STAIRS 58-17

LOUIS P. SAENZ and IGNACIO MARTIN—Oct. 1961, pp. 353-366

The elastic analysis of orthopolygonal stairways in a plane, fixed at both ends, is presented by two different methods. The first method is based on column analogy and Newmark's numerical procedure for computing shears and moments. The second method is based on the determination of the constant second differences of the general expression of the end moments and then, by exact extrapolation, the moment for any number of steps can be obtained. The design of this type of stairway is also discussed.

STRENGTH OF CONCRETE UNDER COMBINED STRESS 58-18

C. J. BELLAMY—Oct. 1961, pp. 367-382

The effect of the intermediate principal stress on the strength of mortar was established for the particular case where the smallest principal stress was zero, by testing hollow cylinders to failure under axial load and confining pressure. The results are compared with some existing failure criteria, and the graphical system of presentation of the criteria examined critically.

ANALYSIS OF VISCO-ELASTIC BEHAVIOR OF CONCRETE STRUCTURES WITH PARTICULAR REFERENCE TO THERMAL STRESSES 58-19

O. C. ZIENKIEWICZ—Oct. 1961, pp. 383-394

The problems of stresses and deformations resulting from imposed loads, displacements, and temperature stresses in a concrete structure are formulated in general terms on the assumption of a visco-elastic behavior of the material. Concrete is assumed to behave as a visco-elastic material with age dependent properties and with a constant Poisson's ratio. Examples illustrating the development of thermal stresses in a simple slab due to the heat of hydration and boundary cooling are presented.

HYPERBOLIC REINFORCED CONCRETE COOLING TOWERS 58-20

PAUL ROGERS—Oct. 1961, pp. 395-406

This paper describes the general features, operation, and economic advantages of the natural draft type, hyperbolically shaped, reinforced concrete cooling towers.

COMPARISON OF PRESTRESSED CONCRETE BEAMS AND CONVENTIONALLY REINFORCED CONCRETE BEAMS UNDER IMPULSIVE LOADING 58-21

G. K. WADLIN and J. J. STEWART—Oct. 1961, pp. 407-422

Pretensioned prestressed concrete beams and conventionally reinforced concrete beams of the same size were subjected to impulsive type loading and to static loading. Dynamic loads reached their peak values in from 0.005 to 0.006 sec. in a specially designed testing machine. Data were recorded with a high speed movie camera operated at speeds of about 2000 frames per sec. Comparisons of the behavior of the two types of concrete beams were based on a frame by frame analysis of the films and correlation with their static destructive tests.

DESIGN OF THE CONTINUOUS ARCHED FRAME SUPPORTING CYLINDRICAL SHELLS **58-22**

ALFRED ZWEIG—Oct. 1961, pp. 423-458

Presents a method for designing continuous arched frames and offers tables for use with the most commonly used loadings, and frame shapes. The method will allow design of these frames, which normally require the simultaneous solution of a number of equations, without great effort. An appendix provides the mathematical derivation of the formulas offered.

ESTIMATION OF HEAT OF HYDRATION OF PORTLAND CEMENT **58-23**

KEN YONG and KUNG JEN-HSIA—Oct. 1961, pp. 459-470

Two methods of estimation of 7- and 28-day heats of hydration of portland cement from analytical data are studied by statistical analysis. In Method I, the heats of hydration are correlated with the calculated compound content, i.e., C_3S, C_2S, C_3A, and C_4AF as the independent variables, and in Method II, they are correlated with the corrected C_3S and C_2S and glass content as calculated by the series of equations derived by Dahl, as the independent variables. Comparisons with observed values show that predicted values calculated by Method II compare favorably with those by Method I, so that estimations can be more accurately and reliably made.

SELECTION AND USE OF AGGREGATES FOR CONCRETE **58-24**

ACI COMMITTEE 621—Nov. 1961, pp. 513-542

Presents available information on aggregates in four categories. (1) Evaluation of aggregate properties in terms of their influence on the properties of concrete. (2) Methods of determining aggregate properties and the limitations of these methods. (3) Features of aggregate preparation and handling which have a bearing on concrete quality and uniformity. (4) Selection of aggregate.

The report is limited to sand, gravel, crushed stone, and air-cooled blast-furnace slag aggregate. Lightweight aggregate and special heavy aggregate are not covered.

PRECAST COMPLEX CONOIDAL HORTICULTURAL DOMES **58-25**

W. JOHN HUFSCHMIDT—Nov. 1961, pp. 543-554

A radical departure from the standard gable type roof design for greenhouses or horticultural exposition buildings was undertaken by the Milwaukee County Park Commission at Mitchell Park in Milwaukee, Wis. There were a number of innovations in design, both from the horticultural, as well as the architectural-structural, point of view.

Describes the design, casting, and erection of one of the typical superstructures of these complex conoidals, or domes, as they are more commonly called.

An interesting aspect was the precasting of the dome sections. The use of concrete molds with loose concrete pieces or cores was selected. Because the large pieces were not in one plane, the molds required loose pieces which had to be released before the finished product could be stripped or removed. The construction of the concrete mold, which followed much the same procedure as used in the foundry industry, is described.

TIE REQUIREMENTS FOR REINFORCED CONCRETE COLUMNS **58-26**

B. BRESLER and P. H. GILBERT—Nov. 1961, pp. 555-570

Mechanism of failure of reinforced concrete columns with lateral ties is described. Rational criteria for spacing and size of lateral ties are derived, and pilot tests verifying some of these criteria are described.

REINFORCED CONCRETE FAILURES DURING EARTHQUAKES **58-27**

ROGER DIAZ DE COSSIO and EMILIO ROSENBLUETH—Nov. 1961, pp. 571-590

Photographic evidence is presented and discussed of different types of failures occurring to reinforced concrete members during earthquakes. For the most part, examples are shown from three recent Mexican earthquakes: the 1956 Oaxaca, the 1957 Mexico City, and the 1959 Coatzacoalcos-Jaltipan. Some examples are also shown from the 1923 Kanto and 1948 Fukui Japanese earthquakes, and from the recent 1960 Chilean earthquakes. The major types of failures observed were shear and diagonal tension, beam or slab-column connection failures, excessive bending, and tension. Most of the damage observed was due to poor construction practices and oversimplifications in the design. However, a study of the photographic evidence makes designers and construction men aware of the major types of damage to guard against. Also, types of failure observed again and again, in different structures and in different regions, point out weaknesses in local building codes.

CRACK PROPAGATION AND THE FRACTURE OF CONCRETE **58-28**

M. F. KAPLAN—Nov. 1961, pp. 591-610

The Griffith crack theory of fracture strength is discussed. Tests were performed on concrete beams with crack-simulating notches, and two methods, which have been called the analytical and the direct experimental methods, were used to determine the critical strain-energy-release rate G_c associated with the rapid extension of the crack. There was good agreement between G_c values for beams with different notch depths and which were loaded both by the third-point and center-point methods. However, 3 x 4 x 16-in. beams gave somewhat larger G_c values than did 6 x 6 x 20-in. beams. Although further research is necessary, the indications are that the Griffith concept of a critical strain-energy-release rate being a condition for rapid crack propagation and consequent fracture, is applicable to concrete. The critical strain-energy-release rate may be ascertained by suitable analytical and experimental procedures and the fracture strength of concrete containing cracks can thereby be predicted.

INFLUENCE OF SAND CONCENTRATION ON THE DEFORMATIONS OF MORTAR BEAMS UNDER LOW STRESSES **58-29**

O. ISHAI—Nov. 1961, pp. 611-624

Slender mortar beams, prepared with different sand concentrations, were subjected to a series of bending tests consisting of instantaneous loading and unloading, to prolonged creep tests, and to strength and density tests, to establish the influence of the volume concentration of the sand on the rheological parameters of the mortar.

Results show that up to a volume concentration of 50 percent, rigidity, density, and strength increase slightly and almost linearly with sand concentration. In addition, the stress-strain relationship is also linear in this range up to failure.

On the other hand, at sand concentrations above 60 percent, a steep decrease was observed for the above properties with increasing concentration as well as deviation from linearity of the stress-strain curve at about 60 percent of ultimate stress. Most of the values reach a maximum in the intermediate range of 50-60 percent.

FULL SCALE TESTING DEVELOPS EFFICIENT PRELOADED CONCRETE PILLARS....58-30

JOHN J. REED and C. DAVID MANN—Nov. 1961, pp. 625-638

Describes an effort to develop stronger, more effective concrete pillars for underground mine support. Experience indicated that pillars that were not preloaded do not carry appreciable loading until roof rock and adjacent rock pillars have begun to fail. An analysis is presented of data collected during construction, testing, and preloading of 10 large prestressed concrete mine pillars.

WELDING OF REINFORCING STEEL BETWEEN PRECAST CONCRETE UNITS....58-31

J. NEILS THOMPSON, HUDSON MATLOCK, and A. ANTHONY TOPRAC—Dec. 1961, pp. 673-694

It has been established that damage to welded splices between unrestrained precast concrete units consisted primarily of cracking due to differential thermal expansions. This study was intended to establish the effects of the controlling variables and to evaluate the damage.

Specimens consisted of pairs of concrete blocks cast with a deformed reinforcing bar projecting from the end of each block. The bars were connected with 60 deg V-butt welds, performed at a reasonably rapid rate.

Temperatures were measured with thermocouples along the steel bars and output voltages of the thermocouples were repeatedly scanned. Crack lengths were measured immediately after welding.

Temperature distributions were found to be primarily functions of the bar projection (distance of weld from face of concrete). They were not affected much by bar size, thickness of cover, or welding procedure. Higher temperatures obtained with bare bars indicated a considerable amount of conduction of heat to the concrete in the regular units.

Bond tests did not show that any significant decrease in strength was due to the cracks formed by welding. Apparently, with the specimens and procedures used, it made little difference whether the initial crack was formed during welding or later by initial loading in the pull-out test.

FIFTY YEAR COMPRESSION TEST OF CONCRETE....58-32

M. O. WITHEY—Dec. 1961, pp. 695-712

In 1910 a test program was undertaken at the University of Wisconsin to obtain information on the effect of age and certain curing conditions on the compressive strength of concrete. Specimens from this investigation were made of two different mixtures and stored under water, out of doors, or indoors. Tests on specimens after 50 years are compared with earlier compression tests results. Increases in compressive strength after 50 years are noted.

EXPERIMENTAL STUDY OF LATERAL STABILITY OF REINFORCED CONCRETE BEAMS....58-33

JAGADISH K. SANT and RICHARD W. BLETZACKER—Dec. 1961, pp. 713-736

The study, which involves both experimental and theoretical phases, provides some basis for the formulation of design provisions for the lateral stability of reinforced concrete beams. Stability criteria, reduced to simplified formulas involving the ratios of L/b and d/b, and based on conservative assumptions, are suggested for three types of loading commonly met in practice. The usefulness of these formulas is limited to the under-reinforced rectangular concrete beams. The experimental study consisted of casting and testing to destruction four groups of identical specimens all having an L/b ratio of 96 and a tensile steel content of approximately 3.85 with d/b ratios varying from 3.78 to 12.45. For the given strength of steel and concrete there exists a critical slenderness ratio, Ld/b^2, beyond which instability is the primary mode of failure reducing the ultimate flexural strength. Experimental results verified the theoretical predictions for the test specimens.

DESIGN OF CONCRETE LININGS FOR LARGE UNDERGROUND CONDUITS....58-34

R. S. SANDHU—Dec. 1961, pp. 737-750

Attention is drawn to the effect of restraint offered by rock to deformation of an underground conduit lining. A method of evaluating the passive pressures and of determining the final moments for design is also given. The principles, in an approximate form, have been successfully employed in the design of the tunnel system of Bhakra Dam, India, achieving considerable economy in reinforcement requirements.

INTEGRAL SODIUM CHLORIDE EFFECT ON STRENGTH, WATER VAPOR TRANSMISSION, AND EFFLORESCENCE OF CONCRETE....58-35

DONALD F. GRIFFIN and ROBERT L. HENRY—Dec. 1961, pp. 751-772

Presents basic data about water vapor permeability of plain concrete and the effects on permeability of certain admixtures such as oleic acid and sodium chloride.

Other variables included in the study are: (1) specific location of specimen disk as cut from a concrete cylinder; (2) maximum size of aggregate and (3) environment of specimen whether in 73.4 F, 20 or 50 percent relative humidity.

Part of the total study includes the results of a quarter replicate statistical experiment for two levels of each of six factors to permit an analysis of variance of different variables in the permeability study.

Salt whisker crystal growth on specimens with sodium chloride as an admixture is discussed.

Test results revealed that water vapor transmission values were found to be significantly higher for the higher water-cement-ratio concretes, the absence of sodium chloride, and the presence of smaller aggregate. Origin of concrete disk within cylinder, presence of oleic acid, and relative humidity were factors found to have no statistically significant effect.

STEADY STATE THERMAL STRESSES IN RIGID FRAMES....58-36

JOSEPH J. GENNARO—Dec. 1961, pp. 773-782

A method is developed for finding the moments and stresses developed in beams and rigid frames subject to linear variations of temperature between the lower and upper edges of the beam. Tables are given which enable the designer to easily compute moments and stresses for a variety of single span symmetric frames with hinged supports. Tables are limited to frames with members of constant cross section but the general method of analysis can be extended to frames with members of variable cross section.

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ACI-ASCE COMMITTEE 326—Jan. 1962, pp. 1-30

Presents a review of scientific knowledge engineering practice and construction experiences regarding shear and diagonal tension in reinforced concrete beams, frames, slabs, and footings. Recommendations for new design procedures are substantiated by extensive test data.

Chapters 1 through 4 deal with background and general principles. Chapters 5 through 7 present the development of new design methods for reinforced concrete members without and with web reinforcement, and for members without and with axial load acting in combination with bending and shear. Chapter 8 deals with slabs and footings including the effect of holes and transfer of moments from columns to slabs.

EDWARD A. ABDUN-NUR—Jan. 1962, pp. 31-46

How good should concrete be to serve its intended purpose?

To answer this, several typical specifications are evaluated statistically relating results from an average project to physical job conditions.

Concludes that minimum strength specifications are unrealistic, not generally met in practice, and tend to obscure the real safety factor. However, specifications based on average strength geared to coefficient of variation, permitting a reasonable number of low strength values, are more realistic, lower costs, reduce maintenance, and permit the safety factor to be determined before construction starts. A probability of 10 to 90 percent of strengths being below design strength provides better concrete than obtained currently under minimum strength specifications.

PING CHUN WANG—Jan. 1962, pp. 47-62

The ultimate resisting moments and corresponding reinforcements of T-beams and rectangular beams, 1 ft wide, are tabulated based on their effective depth. The ultimate load and bending moment for columns with bending in one direction only are plotted for various depths and percentages of reinforcement, assuming the reinforcement is distributed equally at each face normal to the direction of bending. Columns with biaxial bending are solved by adopting simplified and approximate formulas and using the curves for uniaxial loading. Examples are given for solving typical problems.

M. J. HAWKINS—Jan. 1962, pp. 63-72

Reviews the field problems associated with control of mixing water additions to transit-mixed concrete. A test program is described which attempted to determine the effect on concrete strength and durability of additions of water to offset slump loss in operations involving long hauls or delays.

MANUEL SAVRAN—Jan. 1962, pp. 73-84

Charts are presented for simplifying the selection of a symmetrical footing size to satisfy an allowable soil pressure. The charts do not eliminate the necessity of computing soil pressures but do eliminate much of the trial and error normally associated with the selection of a footing size.

PLACIDO CICALA—Jan. 1962, pp. 85-102

Stresses and deflections in shells with hyperbolic paraboloidical (hypar) midsurfaces and straight sides under arbitrary loading and restraint conditions are represented by a combination of (a) a membrane solution, (b) an inextensional solution, and (c) a series of "strip" solutions. The fundamental stress systems are presented and two sample problems illustrate the application of this concept.

ACI COMMITTEE 318—Feb. 1962, pp. 145-276

This code provides minimum requirements for the design and construction of plain, reinforced or prestressed concrete, or composite structural elements of any structure erected under the requirements of the general building code of which this code forms a part. For special structures, such as arches, tanks, reservoirs, grain elevators, shells, domes, blast-resistant structures, and chimneys, the provisions of this code shall govern so far as they are applicable.

This code is written in such a form that it may be incorporated verbatim or adopted by reference in a general building code, and earlier editions of it have been widely used in this manner.

ACI-ASCE COMMITTEE 326—Feb. 1962, pp. 277-334

Presents a review of scientific knowledge, engineering practice, and construction experiences regarding shear and diagonal tension in reinforced concrete beams, frames, slabs, and footings. Recommendations for new design procedures are substantiated by extensive test data.

Chapters 1 through 4 deal with background and general principles. Chapters 5 through 7 present the development of new design methods for reinforced concrete members without and with web reinforcement, and for members without and with axial load acting in combination with bending and shear. Chapter 8 deals with slabs and footings including the effect of holes and transfer of moments from columns to slabs.

ACI-ASCE COMMITTEE 326—Mar. 1962, pp. 353-396

Presents a review of scientific knowledge, engineering practice, and construction experiences regarding shear and diagonal tension in reinforced concrete beams, frames, slabs, and footings. Recommendations for new design procedures are substantiated by extensive test data.

Chapters 1 through 4 deal with background and general principles. Chapters 5 through 7 present the development of new design methods for reinforced concrete members without and with web reinforcement, and for members without and with axial load acting in combination with bending and shear. Chapter 8 deals with slabs and footings including the effect of holes and transfer of moments from columns to slabs.

JAMES O. BRYSON and ROBERT G. MATHEY—Mar. 1962, pp. 397-406

Wide flange structural steel beams with different surface conditions were embedded in concrete and subjected to push-out tests to determine the effect of surface condition on the bond between concrete and steel. The surfaces of the embedded steel beams were either freshly sandblasted, sandblasted and allowed to rust, or left with normal rust and mill scale

The steel beams with a sandblasted surface, and those with a sandblasted surface which was allowed to rust, developed considerably higher ultimate bond stresses than beams with normal rust and mill scale. However, at a free-end slip of 0.001 in. there was no significant difference in the bond stress for all three types of surface conditions.

A. A. BRIEILMAIER—Mar. 1962, pp. 407-426

The general structural action of prismatic folded-plate roofs of simple span is considered without derivations or formulas. A numerical example of a two-unit folded plate roof on a simple span of 56 ft is then analyzed for combined dead and live load by one of the approximate methods, taking account of the effect of plate deflections. The results are obtained in the form of transverse moments in the slab, longitudinal flexural stresses and principal tensile stresses in the plates, and shearing forces between the plates and their end supports. The values obtained for longitudinal flexural stresses at midspan and shearing forces at the supports are compared with those given by the ordinary beam theory.

TEDDY J. HIRSCH—Mar. 1962, pp. 427-452

A general equation is derived which expresses the modulus of elasticity of concrete or mortar in terms of an empirical constant the elastic moduli of the cement matrix and aggregate constituents, and the mix proportions. Laboratory tests showed the equation to produce good results over a wide range of variables. The average deviation was found to be written ±10 percent, and the maximum deviation was within ±35 percent.

The variety of aggregate materials used included steel punchings, crushed glass, lead drops, Ottawa sand, crushed limestone and a calcareous-siliceous river gravel.

IB FALK JORGENSEN—Mar. 1962, pp. 453-462

The purpose of this analytical study is to evaluate the flexural behavior under ultimate load of a cracked section reinforced with tensile reinforcement only. A graphical method is developed to evaluate the stresses and strains in the reinforcement for any shape stress-strain curve. It is shown that the strain in the reinforcement under ultimate load is related to the concrete strength, the steel ratio, and the stress-strain curve of the reinforcement and not, as generally accepted to the steel strength only.

PAUL E. MAST—Apr. 1962, pp. 481-526

Design recommendations accompanied by an analysis example for a long-barrel northlight shell are presented. Simplifying design procedures based on the properties of the lower and the upper edge beam and on the dampened propagation of the boundary disturbances are used to abbreviate the analysis. The mutual influence of the two boundaries and their influence on the membrane state of stress is illustrated.

Construction details and procedures based on European experience with northlight shells are described. Some take-off values are given to reduce the unknowns in cost estimates. Architectural aspects and engineering features are mentioned to familiarize the reader with this shell type which is still rate in the United States.

NORMAN B. GREEN—Apr. 1962, pp. 527-550

Present methods employed for design and construction of prestressed lift slab buildings are discussed. Items covered include stress analysis, losses of prestress, post-tensioning procedure, column design, and design for lateral load resistance.

F. P. WIESINGER and W. T. MARSHALL—Apr. 1962, pp. 551-562

Presents a simplified method of ultimate strength design of rectangular or T-sections controlled by tension. Method applies to sections with or without compressive reinforcement for conditions of bending only or bending with axial load. Equations are presented which express first principles and a universal design chart is given. The method conforms to the requirements of ACI 318-56 and incorporates all the limitations prescribed therein.

ROBERT J. HANSEN and ATIS A. LIEPINS—Apr. 1962, pp. 563-584

Bond strengths of standard deformed reinforcing bars under static and dynamic loadings have been investigated under conditions in which splitting failures have been in-

hibited. The tests have shown that local static bond strengths may be as high as $0.75f'_c$ and that under single pulse dynamic loading at high strain rates this strength increases to f'_c. For all practical lengths of embedment of bars steel failure may be expected under both static and dynamic loading. Such bars loaded dynamically will carry a larger load than bars loaded statically, this increase in carrying capacity being due solely to the increase in steel strength under dynamic loading.

CONTINUITY CONNECTION FOR PRECAST PRESTRESSED CONCRETE BRIDGES.....59-18

EARL D. BISHOP—Apr. 1962, pp. 585-600

A method is proposed by which precast prestressed concrete bridge members may be connected to bring about continuous action under dead loads as well as live loads. The proposed connection consists of steel plates cast into the ends of the precast members and welded together at the supports. The longitudinal slab steel over the supports is designed to resist the live load moments.

INFLUENCE OF SUPPORT CONDITIONS ON THE BEHAVIOR OF LONG RECTANGULAR TANKS.....59-19

J. D. DAVIES—Apr. 1962, pp. 601-608

Describes a method of determining the critical bending moments developed in the cross sections of long rectangular tanks or conduits under different support conditions.

RESEARCH AND PRACTICE.....59-20

LEWIS H. TUTHILL—May 1962, pp. 625-632

Retiring ACI President Lewis H. Tuthill—concrete engineer, Division of Design and Construction, California Department of Water Resources, Sacramento—emphasizes the need for shortening the gap between research and practice.

MAIN LINE REFORM TEMPLE OF WYNNEWOOD, PENNSYLVANIA.....59-21

JACOB J. CRESKOFF—May 1962, pp. 633-644

A post-stressed lightweight concrete dome, a new use of concrete pipe to limit echoes from the dome ceiling to a satisfactory level, completion within the original estimate at a unit cost of $13.45 per sq ft, and unusual speed of construction are notable features of the Main Line Reform Temple project recently completed in Wynnewood, Pennsylvania.

The outstanding unit of the Temple project is the 70 ft diameter sanctuary dome constructed of lightweight concrete 2½ to 4½ in. thick, with 60 percent of its ceiling area covered by concentric rings of concrete pipe anchored monolithically to the dome concrete.

Other unusual features are the two Virendeel trusses, 7 ft deep and 58 ft long, which support the roof girders in the auditorium and also carry the clerestories; and the stained glass panels in the sanctuary, which are composed of 1 in. thick colored glass segments bound together by a 1 in. thick concrete matrix.

CONTROLLED-DEFLECTION DESIGN METHOD FOR REINFORCED CONCRETE BEAMS AND SLABS.....59-22

DONALD G. ALCOCK and ADRIAN PAUW—May 1962, pp. 645-658

Describes a design method for reinforced concrete beams and slabs in which the allowable ratio of span to deflection is a criterion. The method may also be used for estimating deflections in given designs including those in which ultimate strength theory is used. Special emphasis is placed on design with lightweight aggregate concretes. The elastic theory only is used and estimation of the elastic modulus of concrete is based on previous work. A short-cut procedure is presented for the design of simply supported beams and slabs subjected to uniformly distributed loads only. Tables and design charts are furnished to aid computation. The problem of deflection caused by creep and shrinkage of the concrete is mentioned but not directly dealt with in this paper. The examples, therefore, deal with short-time deflections only.

SEMIGRAPHICAL ANALYSIS OF LONG PRESTRESSED CONCRETE VAULTED SHELLS..59-23

ANDREW R. NASSER and CARL B. JOHNSON—May 1962, pp. 659-672

Presents a simple and rational method for the analysis of transverse sections of longitudinally prestressed vaults. The method requires no involved mathematics and is also adaptable to vaults without prestress, for which case its accuracy is compared to that of available analytical solutions. The procedure is valid for long vaulted shells of such proportions that beam action may be assumed to occur.

Whereas a rigorous mathematical solution for prestressed vaults is forbidding, if not impossible in many instances, the graphical approach is simple yet accurate and adaptable to vaults of any section and variable thickness. The method also promotes a physical understanding of the transverse shell action.

INVESTIGATION OF CONTINUOUS WIRE REINFORCEMENT AS A REPLACEMENT FOR BRICK TIES IN MASONRY WALLS.....59-24

S. A. BORTZ and ALBERT LITVIN—May 1962, pp. 673-686

The purpose of this investigation was to provide data on the relative merits of the brick header course versus continuous wire reinforcement in tying the two wythes of a brick and block masonry wall together. In addition to header bricks, two types of wire reinforcement were studied; a truss-type and a tab-type consisting of two parallel wires with a 4 in. wire tab every 15 in.

Studies were made of flexural strength in the vertical direction, compressive strength and water permeability. The strength investigation was made on both 8- and 12-in. walls, using the three types of ties.

A technique was developed to measure resistance to water penetration of 8-in. walls. This consisted of a chamber bolted to the face of the wall in which a positive pressure of 20 or 35 lb per sq ft could be maintained while a sheet of water was flowing over the face of the specimen.

Results of this study indicate that (1) the use of continuous wire reinforcement will produce brick and block walls that are as strong as brick header-tied walls, and (2) the wire-tied walls are less permeable than header-tied walls.

SHRINKAGE AND CREEP INFLUENCE OF DEFLECTIONS AND MOMENTS OF REINFORCED CONCRETE BEAMS.....59-25

HANS GESUND—May 1962, pp. 687-704

The long term deflection behavior within the working load range of reinforced concrete beams is analyzed. The effects of creep and shrinkage are included by resolving the total compressive strain into its constituent parts. It is shown that, due to shrinkage, the planes of zero stress and zero strain no longer coincide in the beam, and that their locations depend on the concrete stress and thus on the

moment. The nonlinear relations between moments and stresses are then derived. Fortunately, it turns out that the relation between moment and the sum of the strains remains almost linear and can often be expressed by $AM + B = \Sigma\epsilon$ where A and B are essentially constant for large ranges of M. The above expression can be integrated with various boundary conditions to obtain deflections of simple beams, and fixed-end moments and deflections of statically indeterminate beams. Due to the second constant, B, in the equation, a part of the deflection is shown to be independent of the load.

MOMENTS IN COMPOSITE BEAM BRIDGES BY ORTHOTROPIC PLATE THEORY **59-26**

KUANG-HAN CHU and G. KRISHNAMOORTHY—May 1962, pp. 705-722

The effect of the shearing force between the beams and the slab in a composite beam bridge was taken into account by considering the beams and the slab acting together as an orthotropic plate. It was found that beam moments computed according to the current highway bridge design specifications are on the conservative side.

PROPOSED ACI STANDARD MINIMUM REQUIREMENTS FOR THIN-SECTION PRECAST CONCRETE CONSTRUCTION **59-27**

ACI COMMITTEE 324—June 1962, pp. 745-756

These minimum requirements pertain to design and construction of precast concrete structural elements the thickness of which is less than that permitted by standard building codes for use in normal fire-resistant structures, but is in no case less than 1 in. The use of either normal, moderate sulfate-resisting, or high-early-strength cement is permitted. Special grading limits for coarse aggregate are cited, and specifications for reinforcement and admixtures are given. Concrete of 4000-psi strength is specified for protected locations not in contact with the ground; 5000-psi concrete for other locations. Limits for air content, water-cement ratio, and cement content are given. Accurate placing of reinforcement is emphasized, and the amount of cover is stated.

Fabrication is discussed in provisions on mixing, molds, casting, curing, surface treatment, and tolerances of individual elements. Supervision and inspection during fabrication are stressed, with some requirements for acceptance. Method and sequence of erection are also treated, including connection devices, assembly tolerances, and weatherproofing of joints.

Differences in certain requirements from those given for normal fire-resistant structures in ACI 318 and ACI 711 are pointed out and the reasons therefor explained.

COLUMN STRENGTH OF LONG PILES **59-28**

J. J. HROMADIK—June 1962, pp. 757-778

Results of full-scale column tests on 80 ft long concrete piles (nominally 60 ft unsupported length), concentrically loaded, are presented. Included are 32 tests of 12 separate concrete specimens (three each of four different types); test data on three steel bearing piles are also given for comparison.

The test results on the concrete specimens are compared to theoretically predicted buckling loads determined by employing Engesser's tangent modulus in the generalized Euler equation and using test determined effective lengths. The application of the tangent modulus principles is in accordance with the works of others, who utilized Hognestad's idealized stress-strain relation for concrete. The analyses indicate that there is no evidence of a significant difference between the theoretical predictions and the test results.

ECONOMICS OF FORMWORK PLANNING **59-29**

JOSEPH R. PROCTOR—June 1962, pp. 779-802

Elements which enter into cost of formwork include such diverse items as scheduling, job specifications, form materials, labor involved in building forms, labor involved in placing and removing forms, handling methods and equipment for re-uses, hardware, safety, and many other details. Each factor may affect the forming methods selected for a job and, conversely, may be affected by the forming methods. These various components that make up form cost are examined, as are effects of job conditions. A check list of form planning considerations is offered. Examples illustrate factors in figuring form cost. The form planning for a bridge job involving a number of concrete piers is described in detail.

AN UNUSUAL CASE OF FREEZING OF FRESH CONCRETE **59-30**

EDWARD A. ABDUN-NUR and RICHARD C. MIELENZ—June 1962, pp. 803-814

An unusual example of freezing of fresh concrete in floor slabs has been observed in the Platteville Elementary School Building, Platteville, Colo., built in the fall of 1957. Initial evidence of distress was numerous, closely spaced bumps in the finished surface of the floors. These protuberances are especially disturbing in areas of tiled floor, where they were first noted.

Detailed examination of the floor slabs, both at the site and by microscopical examination of drilled cores, showed that the upper ½ to 1¼ in. of the concrete had been frozen before hardening, causing intense fracturing of the near-surface portion and producing bumps over originally frozen lumps of sand and shale incorporated in the concrete. It is concluded that the bumps formed as a result of growth of ice lenses within and adjacent to the frozen lumps. The irregularities of the floor surfaces have increased progressively with time in areas of concentrated traffic, because of disintegration of the highly fractured near-surface concrete beneath the floor tile under the impact of heavy foot traffic.

DIFFERENTIAL TEMPERATURE MOMENTS IN RIGID FRAMES **59-31**

PAUL FISCHER—June 1962, pp. 815-842

Methods of analysis for bending moments in one story rigid frames and arches due to transverse differential temperatures are presented. Use is made of temperature distribution diagrams analogous to moment diagrams to obtain fixed-end moments and deflections for straight members. Formulas are developed giving deflections and angle changes for both straight and curved members fixed at one end and free at the other. Examples are given in which members of both constant and variable depth are used. The moment distribution method is used for analysis of a tunnel section and the column analogy is used for the moment analysis of an arch and a one-story frame.

BARREL SHELL ROOF USED FOR TWO NATATORIA IN CHICAGO **59-32**

DIMITRI NESTERENKO and HAROLD SOMMERSCHIELD—July 1962, pp. 873-886

The use of reinforced concrete barrel shells for the roof over natatoria, or swimming pools, provides a utilitarian and esthetically attractive structure. An area approximately 90 x 112 ft is covered by each of these shells. Basic design characteristics and construction procedures are discussed. Methods used to solve unusual subsurface conditions encountered, and winter construction precautions are reviewed.

DEVELOPMENT LENGTH OF HIGH STRENGTH REINFORCING BARS IN BOND.....59-33

PHIL M. FERGUSON and J. NEILS THOMPSON—July 1962, pp. 887-922

A new type test beam was used to place the development length of the bar in a negative moment region such that the maximum steel stress and average bond stress could be calculated. Bars were high strength steel, yield point of 75 kips per sq in. of #3, #7, and #11 size, with and without stirrups. Typically, bars split out in bond, but diagonal tension was often a complicating factor. The developed bond stress was lower as the development length for larger bars was increased, but the bond stress showed to be primarily a function of length rather than of bar size. Ultimate bond stress varied as $\sqrt{f'c}$ when other factors were constant. Bar cover and beam widths were important factors. End anchorage was reasonably effective but seemed to increase the cracked widths observed.

CREEP MECHANISM IN CEMENT MORTAR.....59-34

JOSEPH GLUCKLICH and ORI ISHAI—July 1962, pp. 923-948

A series of tests with a view to determining the true causes of concrete creep was carried out on cement mortar specimens. After drying and insulation from the atmosphere, specimens with varying water content were loaded in torsion and the instantaneous and time-dependent deformations measured.

Results have shown a close connection between the evaporable water content of the specimen on the one hand and the shrinkage, instantaneous deformation, and creep on the other. The most outstanding phenomena observed were the mutual dependence of the evaporable water and creep, the linear relation between gel water and the rate of creep and the almost complete disappearance of creep in specimens from which most of the evaporable water has been removed.

As a main conclusion of the tests, the mechanism of creep is interpreted in terms of water migration within the voids of the specimen due to the action of the external load.

This is followed by a theory providing a qualitative and quantitative explanation of the relation between the evaporable water content and the creep and instantaneous deformation, on the basis of the rheological behavior of a porous elastic body containing liquid in its voids.

MASS PRODUCTION OF SHELLS FOR THE OAKLAND INTERNATIONAL AIRPORT.....59-35

ISADORE THOMPSON—July 1962, pp. 949-958

All major roof elements of the terminal and ticketing buildings of the Metropolitan Oakland International Airport are precast shells. Two basic types were developed; hyperbolic paraboloids for the terminal building and conoidal shaped barrel vaults for the ticketing building. The design and construction of these shells is described. The airport will serve the eastern San Francisco Bay area.

MULTISTORY FRAME ANALYSIS FOR VERTICAL LOADING.....59-36

G. I. N. ROZVANY and A. J. K. HAMPSON—July 1962, pp. 959-966

Building codes and textbooks state that in computing moments in multi-story frames for vertical loading, considering one particular floor, the far ends of the columns may be assumed as fixed. An examination of the computations for most rigid building frames in Melbourne, Australia, showed that this assumption may result in considerable error.

It is suggested that by multiplying the column stiffness by 1.5 in the original assumption, accurate results can be obtained for intermediate stories.

By applying the concept of equivalent stiffness to infinite frames, the magnitude of error of these methods is determined and an example worked.

PROPOSED RECOMMENDED PRACTICE FOR CONCRETE FORMWORK.....59-37

ACI COMMITTEE 622—Aug. 1962, pp. 993-1046

Presents brief introductory statement on the need for formwork standards based on the fact that 35 to 60 percent of the total cost of the concrete work in a project in the United States is in the formwork. A section is given on engineer-architect specifications noting the kind and amount of specification the engineer or architect should provide the contractor. Since the committee concludes that formwork design and engineering, as well as construction, must be the responsibility of the contractor, the recommendations contained in the report are directed to that group. However, an understanding of these recommendations by engineers and architects will aid these groups in their specification functions.

The report is divided into five chapters: 1. Design, 2. Construction, 3. Materials for Formwork, 4. Forms for Special Structures, and 5. Formwork for Special Methods of Construction.

YOU CAN RAISE THE ROOF WITH CONCRETE.....59-38

NELSON A. FAERBER—Aug. 1962, pp. 1047-1054

A description of the design and construction of a shell roof for a residence. The eight-section roof, cast on the site, presented the designers with some interesting public relations problems in addition to those normal to construction. The idea of placing 88 tons of precast concrete overhead was too novel for residents of the small Florida resort community to accept immediately.

The roof covers 3360 sq ft and is 4 in. thick.

CONTRIBUTION TO THE ANALYSIS OF COUPLED SHEAR WALLS.....59-39

HUBERT BECK—Aug. 1962, pp. 1055-1070

If two similar shear walls are arranged one after the other in the same plane, and are connected by rigid beams, they form a highly indeterminate frame system. Such systems are often used to resist wind forces in slender reinforced concrete structures.

This paper presents an approximate method of analysis where a continuous system replaces the discontinuous frame system. Using the method one arrives at simple formulas for the determination of statically redundant values. The method takes into account the shear wall deformations due to normal forces. Beginning with five floors, the accuracy of the results is sufficient for practical application and it increases with a larger number of floors.

Charts are presented for the case of two shear walls tied together, having the same rigidity, and subject to a constant linear horizontal force.

MEASUREMENT OF THE WORKABILITY OF CONCRETE.....59-40

U. T. MEYER—Aug. 1962, pp. 1071-1080

This investigation examines the measurement of the workability of a concrete mass. The concrete was compacted on a vibrating table and the compaction recorded. The area under the resulting curve was measured with a

planimeter. This area is a realiable measure for the useful part of the applied work. The area at the end of the compaction is so small that any prolonged vibration, or uncertainty about the endpoint of the compaction period, have practically no influence on the result, and that was the deciding point in developing and using this workability test method.

To compare these results with usual workability tests, the slump and the Vebeseconds of each concrete were measured.

CONCRETE USAGE IN ATOMIC POWER REACTOR SUPPORT.....59-41

ARTEMY A. WACHRAMEEFF and ROBERT D. CHELLIS—Aug. 1962, pp. 1081-1094

Triple purpose use of a concrete structure at an atomic power plant as a support for the reactor, as a biological radiation shield, and as a missile shield is described. Reasons are given for selecting conventional-aggregate concrete, instead of "heavy" concrete, around and under the reactor to retain radioactive emissions passing through the tank walls and surrounding water.

A spherical shell selected to form the vapor container is carried on a ring of support columns resting on individual footings. The columns of the reactor support pierce this sphere surrounded by gas-tight bellows seals. This construction isolates the sphere from the effects of differential expansions and settlements of the reactor structure and permits use of a relatively thin, unlined steel shell.

The design basis for the concrete support is given, including effects of creep and differential settlements. Also considered are possible serious consequences of applying standard allowable unit shear values to concrete members which may sometime be in net tension over the entire cross section because of differential settlements.

JACKS SPRING SHELL OFF FORMWORK.....59-42

HANNSKARL BANDEL—Aug. 1962, pp. 1095-1104

Design and construction features of the hyperbolic paraboloidal shell that roofs the central court of the National Library of Medicine at the National Institute of Health, Methesda, Md., are described. The four segments of the saddle-shaped roof cover an area 97 x 97 ft. and rise 23 ft. above the main portion of the building.

The sag of the gable frames of the shell caused a problem. Since a major part of this deformation was due to bending in the supporting columns, an artificial, counter displacement was introduced. The introduction of the deflection had the effect of springing the shells off their formwork.

GUIDE FOR USE OF EPOXY COMPOUNDS WITH CONCRETE.....59-43

ACI COMMITTEE 403—Sept. 1962, pp. 1121-1142

Describes proper procedures for the use of epoxy resin compounds for skid-resistant overlays, waterproofing, patching, crack and joint sealing, bonding new concrete or hardened concrete to old concrete, grouting, coatings to prevent chemical attack and other uses. Methods of surface preparation of both concrete and steel, removing contamination prior to applying epoxy compounds, and for applying the epoxy resin compound are described. A test for appraising the soundness of the concrete surface and adhesion to it is suggested. Since epoxy compounds are often toxic, safe handling practice is extensively discussed.

SHEAR STRENGTH OF TWO-SPAN CONTINUOUS REINFORCED CONCRETE BEAMS WITH MULTIPLE POINT LOADING.....59-44

ROBERT H. BRYANT, ALBERT C. BIANCHINI, JOSE J. RODRIGUEZ and CLYDE E. KESLER—Sept. 1962, pp. 1143-1178

Presents results of tests on 21 rectangular, two-span continuous reinforced concrete beams with more than two concentrated loads per span.

Series I studied the accuracy of web reinforcement designed by ACI 318-56. Series II studied behavior and mode of failure with low precentages of web reinforcement.

Variables included type of loading, cutoff or extension of longitudinal reinforcing, and percentage and spacing of web reinforcement.

Behavior of the beams before and after first diagonal tension cracking and at failure is described. Beams with web reinforcing according to ACI 318-56 failed in flexure. Some signs of crushing of the concrete were seen at all center supports.

Five beams of Series II failed in flexure; four, with lower percentages of web reinforcing, had shear compression or splitting bond failures.

Beams without web reinforcement failed in some fashion other than flexure and the failure zone was unpredictable.

DESIGN AND CONSTRUCTION GUIDE FOR PRECAST STRUCTURAL CONCRETE.....59-45

J. L. PETERSON—Sept. 1962, pp. 1179-1204

This paper is based on a report prepared by the Precast Concrete Subcommittee of the Research Committee of the Structural Engineers Association of Southern California (SEAOSC) published in 1958. The paper is a guide to the design and construction of precast concrete buildings and covers materials, tests, controls, design, manufacture, handling, erection, connections, drawings, and supervision. Special attention is given to seismic resistance by combinations of precast concrete units.

GUIDE FOR CONSTRUCTION OF CONCRETE FLOORS ON GRADE.....59-46

ACI COMMITTEE 332—Oct. 1962, pp. 1377-1390

This report of ACI Committee 332, Recommended Practice for Residential Concrete Work, was prepared to serve as a guide for the installation of concrete floor slabs on grade inside residences. The main concern of the committee is one- and two-family dwelling construction. The report is not offered as a specification but as a guide to sound practices.

The report is concerned with the requirements of the site; required quality of materials; mixing, placing, and curing the concrete; design of the slab; and special considerations as related to this particular type of construction.

A COOPERATIVE LABORATORY STUDY OF THE EFFECT OF TESTING ENVIRONMENT AND SPECIMEN TYPE ON SHRINKAGE OF MASONRY UNIT CONCRETE.....59-47

ACI COMMITTEES 716 and 213—Oct. 1962, pp. 1391-1434

Shrinkage of concrete masonry units, an important factor in cracking of walls, has commonly been measured on full-size units by methods which may require from 1 to 3 months to complete. ACI Committees 716 and 213 undertook a cooperative test program in 1958 to evaluate three methods—Reference, Modified British, and Rapid—using whole specimens, face shells, and thin, horizontal slices. The major comparisons required 720 specimens from 10 lots of commercially produced block made of five aggregates by two different curing methods. The Rapid method was adjudged unsatisfactory because of poor correlation with the results of other methods. The Modified British and Reference methods were found to be in substantial agree-

ment in most instances. Face shell specimens cut longitudinally were found to give shrinkages comparable to those for whole block. The use of face shells cut longitudinally and tested by the Modified British method can result in testing economies of both space and time. A statistical analysis is presented.

W. HOWARD GERFEN and JOHN R. ANDERSON—Oct. 1962, pp. 1435-1442

A brief review of connections for precast concrete wall panels. Describes three kinds of connections to cast-in-place column, a connection to precast columns, a connection to steel columns, a splice connection between wall panels, and a welded tie detail.

K. T. SUNDARA RAJA IYENGAR—Oct. 1962, pp. 1443-1466

A theoretical solution for the two-dimensional theory of anchorage zone stresses in post-tensioned prestressed concrete beams is presented. In the light of this solution, the theories of Guyon, Morsch, Sievers, and others are critically examined.

F. J. VAN DEN BERG—Oct. 1962, pp. 1467-1478

Data are presented on experimental investigations into the distribution of shear stresses over a cross section of a reinforced concrete beam. Special attention was given to the determination of the maximum diagonal tension due to shear only.

Tests were carried out on two beams containing only tension reinforcement. The beams were subjected to two concentrated loads and superimposed bending moments.

The results indicate that the nominal shear stress is a reliable measure of the maximum diagonal tension due to shear. Within the scope of the investigation, there is a linear relationship between the applied shear force and the maximum diagonal tension.

AURELIO BENASSINI and FEDERICO BARONA DE LA O—Oct. 1962, pp. 1479-1488

The main curtain and foundation grouting of the Benito Juarez Dam, Mexico, is discussed. Data on borings, stage depths, series spacing, pressure, and amount of grout are given.

JOHN R. VERNA and THOMAS E. STELSON—Oct. 1962, pp. 1489-1504

Sixty reinforced concrete beam specimens were tested to destruction under repeated loading. These specimens were 78 in. long, 5 in. wide and 4, 5½, or 7 in. deep. They were simply supported over a 72-in. span and loaded at the third points. The test data are for the loading conditions of repeated cyclic loading from 10 percent of ultimate static load to a maximum until failure or 1,000,000 cycles. If no failure occurred the maximum load was increased and the program was repeated.

The data are presented with parameters for nominal shear stress, nominal bond stress, concrete compression stress and steel tension stress. The interaction of the different modes of failure were interpreted in terms of these stresses. These tests indicated that bond is the mode of failure most susceptible to fatigue damage and that shear or diagonal tension failures are likely to occur if the specimens are not weak in bond. They showed, also, that the mode of fatigue failure depended on the load level as well as the static failure mode.

ACI COMMITTEE 325—Nov. 1962, pp. 1569-1586

This progress report presents brief data on the design and performance of recently constructed continuously reinforced concrete pavements constructed in Michigan, Maryland, Texas, Wisconsin, Maine, and Pennsylvania. Included are a description of experimental special terminal joint provisions and end anchorages, a summary of theoretical developments for selection of slab thickness and reinforcement, and a summary of present recommendations for design. The report concludes with recommendations for future research.

F. J. VAN DEN BERG—NOV. 1962, pp. 1587-1600

Data are presented on the shear strength of 44 simply supported beams. Tests were carried out in four series with the following variables: (1) concrete strength, (2) shear span, (3) ratio of shear span to effective depth of beam and the effect of end-anchorage, and (4) percentage of tension reinforcement.

The beams were tested under two symmetrical concentrated loads. All the beams failed in shear after diagonal tension cracks formed in the region of maximum shear. The magnitudes of loads causing initial diagonal tension cracks depend on the strength of the concrete, the percentage of tension reinforcement, ratio of shear span to effective depth and the cross section of the beam.

The results indicate that the strength of beams with a/d ratios greater than two may be governed by the load causing the first main diagonal crack.

KURT BILLIG—Nov. 1962, pp. 1601-1634

Presents basic information on concrete pressure vessels. While written for vessels used in nuclear power stations of the British type, many of the conclusions are also applicable to other types. Considers the major factors of heat, the prestressing process, and plastic deformations. General design principles are emphasized.

ACI COMMITTEE 116—Dec. 1962, pp. 1761-1770

As part of its mission, ACI Committee 116, Nomenclature, presents the first part of a glossary of terms on cement and concrete technology. Increment 1 contains those terms in the alphabetical list beginning with A and B. This and subsequent increments are intended to elicit discussion. After the list is completed by increments the committee will combine the separate parts for possible consideration as an ACI Standard.

DURABILITY OF CONCRETE IN SERVICE 59-57

ACI COMMITTEE 201—Dec. 1962, pp. 1771-1820

This report presents recommendations for materials and methods to obtain concrete with maximum resistance to deterioration, to preserve concrete against deterioration, and to restore deteriorated concrete. The report specifically excludes consideration of erosion in hydraulic structures and fire resistance of concrete which are in the province of other ACI committees. Recommdations are made with respect to freezing and thawing, the use of chemicals for ice removal, aggressive chemical agents, abrasion, corrosion of steel, reactive aggregates, and the restoration of deteriorated concrete.

PROPOSED REVISION OF BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE (ACI 318-56)—AMENDMENT 59-58

ACI COMMITTEE 318—Dec. 1962, pp. 1821-1848

Presented here is an amendment to "Proposed Revision of Building Code Requirements for Reinforced Concrete (ACI 318-56)," which appeared in the February, 1962, ACI JOURNAL. Included with this amendment are discussion and reasons for the changes.

SHEAR STRENGTH OF REINFORCED CONCRETE BEAMS WITHOUT WEB REINFORCEMENT. PART 3—PROPOSED METHOD FOR CALCULATION OF CRACKING LOAD 59-59

F. J. VAN DEN BERG—Dec. 1962, pp. 1849-1862

From the results of experimental studies reported in Parts 1 and 2 of this paper, an expression is derived for the calculation of the load at which diagonal tension cracks form. Special attention was given to the effect of flexural stresses on the cracking load. This involved the application of superimposed bending moments, which were varied independently of the shear loads. The results indicate that the total bending moment at the critical section does not always contribute towards the formation of the main diagonal tension crack.

V.60 SYNOPSES

Institute papers and reports of Proceedings V. 60 (January-December 1963 ACI JOURNAL)

WEN F. CHANG and PHIL M. FERGUSON—Jan. 1963, pp. 1-26

Theoretical analyses are presented in this study for both eccentrically and concentrically loaded, long reinforced concrete columns under short-time load. The treatment of concentrically loaded columns is based on von Karman's theory and Hognestad's stress-strain relationship for concrete. Separate equations are derived and plotted for column moment and for load, each in terms of edge strains. By correlation between these curves, moment-versus-edge-strain curves are then plotted for specific values of column load. For a given critical column load, the deflected shape and length and the end slope of the deflected column are next determined by numerical integration of the moment-versus-edge-strain curve. The eccentrically loaded column utilizes a portion of the same solution.

To confirm this numerical method six columns were tested. The test results agree reasonably with the theoretical curves.

ISRAEL NARROW AND ERIK ULLBERG—Jan. 1963, pp. 27-38

Data are presented which show the correlation between flexural strength of concrete beams and tensile splitting strength of concrete cylinders. The concrete mixtures were made with a number of different aggregate types and cements. Cement contents ranged from 4 1/2 to 7 bags per cu yd of concrete. Comparative cylinders and beam specimens were made from the same concrete batches, and tested after moist curing for 7, 14, 28, and 90 days. The test results indicate that there is a good correlation between the flexural strength of concrete beams and the tensile splitting strength of concrete cylinders made from the same concrete. Data also are presented which show that the established correlation is suitable for determining flexural strength of concrete pavements from tensile splitting tests of cores drilled from the pavements.

ROY W. GILLETTE—Jan. 1963, pp. 39-50

A number of bonded overlays using portland cement grout have been employed in resurfacing pavements since 1954. This paper presents results of a survey on a number of these pavements to ascertain the performance of the overlays. The overlays were sounded and their surfaces inspected visually. Cores were taken to confirm areas of bond distress. Some of the specific projects surveyed are described.

The introduction to the paper outlines some of the more important published material on the proper methods and techniques of bonding new concrete surfaces to old concrete surfaces.

BORIS BRESLER and A. C. SCORDELIS—Jan. 1963, pp. 51-74

The general behavior, cracking loads, and strength observed in the tests of a specially designed series of 12 beams are discussed. The tests were designed to provide needed data regarding the shear strength of beams having normal to low percentages of web reinforcement (rf_v = 0, 50, 75, 100) and normal to high shear span ratios (a/d = 4, 5, 7).

Experimental values of strength are compared with calculated values using an empirical equation based on previous test data. Nine of the 12 beams failed in shear and developed strengths from approximately 30-50 percent greater than the calculated values. The remaining three beams failed in flexure and developed strengths in excess of both the calculated flexural and shearing capacities.

A simplified equation is proposed as adequately predicting the shear strength of beams of normal proportions.

J. A. HANSON—Jan. 1963, pp. 75-100

Describes an investigation of the effect of various steam curing procedures on the compressive strength, indirect tensile strength, and elastic properties of concrete, with particular emphasis on steaming procedures compatible with the time requirements of modern prestressing plants. In the usual operation of these plants the time lapse from casting to steam shutoff remains nearly constant at 18 hr. Consequently this investigation generally varied the delay prior to steaming from 1 to 7 hr and the steaming periods from 17 hr down to 11 hr. The rate of steam room temperature increase varied from 20 to 80 F per hr up to three maximum temperatures, 125, 150, and 175 F.

The data have shown that optimum values of these characteristics are obtained with a presteaming of approximately 5 hr combined with a temperature rise rate of 40 F per hr up to a constant temperature of about 150 F. A maximum temperature of 175 F provided only moderate additional benefit.

This steam curing study has emphatically demonstrated the adverse effect of delays in the neighborhood of only 1 hr. If such early application of steam is required by plant procedure, the temperature rise rate should be limited to 20 F per hr or less.

JOSEPH SCHWAIGHOFER and NORBERT SEETHALER—Jan. 1963, pp. 101-112

The design of a highly economical precast and prestressed folded plate was carried out using a model. Emphasis was placed on the determination of the most economical tie spacing and the over-all performance of the unit. The model analysis was succeeded by a study of the behavior of a 7 ft wide and 46.67 ft long unit which was precast and post-tensioned. The performance of the post-tensioned unit was in close agreement with the behavior predicted by the plastic model, in particular the tie forces as established by the model compared favorably with the tie forces measured on the prototype.

EARL W. FOWLER and D. W. LEWIS—Jan. 1963, pp. 113-128

Tests were conducted to evaluate the effect of increased cement contents, decreased slumps, and use of water-reducing admixtures on the strength of air-entrained concrete made with air-cooled, blast-furnace slag aggregate.

Results obtained show that both increased cement content and decreased slump (compared to mixes ordinarily

used) result in large increases in flexural strength of paving concretes and in compressive strength of structural concretes. An admixture of the hydroxy-carboxylic acid type was effective in increasing strengths of the slag mixes and appeared to have the greatest influence on compressive strength and in the richer mixes.

Data on drying shrinkage, tensile splitting strengths, and moduli of elasticity were obtained for part of the tests and limited studies of the effects of aggregate size and type of aggregate were included.

FAILURE SURFACES FOR MEMBERS IN COMPRESSION AND BIAXIAL BENDING **60-8**

F. N. PANNELL—Jan. 1963, pp. 129-140

Two equations are examined which can be used to define the load-moment surface at failure of biaxially loaded columns with equal steel in each face. The use of transformed failure surfaces is extended to cover symmetrical columns with unequal steel in adjacent faces.

POROSITY OF HARDENED PORTLAND CEMENT PASTE **60-9**

W. C. HANSEN—Jan. 1963, pp. 141-156

Discusses the structure of hardened portland cement paste from the standpoint of solid state reactions as opposed to through solution reactions and coagulation of a sol to produce a gel. This is followed by calculations designed to determine the nature of the reaction products from data for the evaporable and nonevaporable water contents of the hardened paste. On the assumption that C_3S and C_2S react with water in the paste to form $C_3S_2H_3$ which contains one mole of evaporable water and two moles of non-evaporable water, the calculations based on estimated densities suggest that the C_4AF and the portion of the C_3A which is not combined as calcium sulfoaluminate react with water and CH to form C_4AH_{19} and C_4FH_{19} or possibly solid solutions of these compounds. These calculations also suggest that about one-half of the space determined as porosity by the value obtained for evaporable water content is occupied by uncombined water in the saturated hardened paste and that the remaining one-half is space occupied by combined water in crystals.

RECOMMENDED PRACTICE FOR CONCRETE FORMWORK (ACI 347-63) **60-10**

Announcement of ACI standard

ACI 347-63 supersedes Title No. 59-37

ACI COMMITTEE 347—Jan. 1963, pp. 169-170

Presents brief introductory statement on the need for formwork standards based on the fact that 35 to 60 percent of the total cost of the concrete work in a project in the United States is in the formwork. A section is given on engineer-architect specifications noting the kind and amount of specification the engineer or architect should provide the contractor. Since the committee concludes that formwork design and engineering, as well as construction, must be the responsibility of the contractor, the recommendations contained in the report are directed to that group. However, an understanding of these recommendations by engineers and architects will aid these groups in their specification functions.

MINIMUM REQUIREMENTS FOR THIN-SECTION PRECAST CONCRETE CONSTRUCTION (ACI 525-63) **60-11**

Announcement of ACI standard

ACI 525-63 supersedes Title No. 59-27

ACI COMMITTEE 525—Jan. 1963, pp. 171-172

These minimum requirements pertain to design and construction of precast concrete structural elements the thickness of which is less than that permitted by standard building codes for use in normal fire-resistant structures, but is in no case less than 1 in. The use of either normal, moderate sulfate-resisting, or high-early-strength cement is permitted. Special grading limits for coarse aggregate are cited, and specifications for reinforcement and admixtures are given. Concrete of 4000-psi strength is specified for protected locations not in contact with the ground; 5000-psi concrete for other locations. Limits for air content, water-cement ratio, and cement content are given. Accurate placing of reinforcement is emphasized and the amount of cover is stated.

Fabrication is discussed in provisions on mixing, molds, casting, curing, surface treatment, and tolerances of individual elements. Supervision and inspection during fabrication are stressed, with some requirements for acceptance. Method and sequence of erection are also treated, including connection devices, assembly tolerances, and weatherproofing of joints.

Differences in certain requirements from those given for normal fire-resistant structures in ACI 318 and ACI 711, are pointed out and the reasons therefor explained.

TRAINING COURSES FOR CONCRETE INSPECTORS **60-12**

ACI COMMITTEE 311 Feb. 1963, pp. 173-182

Trained concrete inspectors are essential if concrete construction of acceptable quality and appearance is to be attained. Periodic training courses are a must to make certain the inspector has the requisite knowledge and training. In this report by ACI Committee 311 (611), Inspection of Concrete, procedures and information which would be useful in a training course for concrete inspectors are given. The report tells how to conduct the course and lists typical past courses and suggested topics. Also included are suggested textbooks, lists of references, and available films and slides.

SHEAR STRENGTH OF BEAMS WITHOUT WEB REINFORCEMENT CONTAINING DEFORMED BARS OF DIFFERENT YIELD STRENGTHS **60-13**

ROBERT G. MATHEY and DAVID WATSTEIN—Feb. 1963, pp. 183-208

The behavior of reinforced concrete beams failing in shear was investigated in a series of tests in which the shear span to depth ratio and the ratio of reinforcement were varied. Six types of deformed bars with nominal yield strengths ranging from 40,000 to 100,000 psi and different stress-strain characteristics were used as tensile reinforcement.

The diagonal tension crack formed in all beam specimens at stresses in the reinforcement which were within the range that was essentially elastic. For beams with the same shear span to depth ratio, the shear strengths at diagonal tension cracking decreased roughly linearly as the corresponding maximum stresses in the reinforcement increased.

An empirical formula is presented for estimating the shear strength corresponding to the diagonal tension cracking load of beams rectangular in cross section without web reinforcement. The shear strengths developed in the beam specimens are compared with values given in the 1956 ACI Building Code and with values computed from the formula recently proposed by ACI-ASCE Committee 426 (326), Shear and Diagonal Tension.

MICROCRACKING OF PLAIN CONCRETE AND THE SHAPE OF THE STRESS-STRAIN CURVE **60-14**

THOMAS T. C. HSU, FLOYD O. SLATE, GERALD M. STURMAN, and GEORGE WINTER—Feb. 1963, pp. 209-224

Internal cracking of plain concrete observed directly with a microscope and with x-ray photographs is reported. Cylinders were axially loaded in compression to various

strains from 0 to 0.0030. Thin slices were made from the strained specimens, and internal cracks examined by newly-developed techniques. Cracks at the interface between coarse aggregate and mortar are widespread even in nonloaded concrete. These "bond" cracks are preponderate at all stages of straining, while mortar cracks begin to increase noticeably, and bridge between bond cracks to form continuous crack patterns at loads of about 70 to 90 percent of ultimate. This condition leads to a descending stress-strain curve and eventual disruptive failure. Correlation with previous investigations by others is shown. Hypotheses concerning the relation between microcracking and the shape of the stress-strain curve are presented.

STRUCTURAL DESIGN OF CONCRETE OVERLAYS **60-15**

FRANK M. MELLINGER—Feb. 1963, pp. 225-238

The structural design of concrete overlay pavements is illustrated by applying a specific method of design to the evaluation of the results of traffic loadings on full-scale concrete overlay test pavements. Traffic loadings varied from 60,000 lb on a single wheel to 325,000 lb on a twin-tandem wheel configuration. Results of these loadings on 11 different overlay test items are described and used in the evaluation, and the relationship between the design requirement and the evaluation is discussed.

DIRECT DESIGN OF PRESTRESSED CONCRETE MEMBERS **60-16**

KOLBJORN SAETHER—Feb. 1963, pp. 239-260

Presents a tool for the design of prestressed concrete members. A series of mathematical derivations are presented showing the step by step procedure from given loads and stresses to the corresponding resulting cross section. This section is subsequently checked for compliance with the ultimate load requirements. A design program and a design example are given with a short discussion of its practical application.

A long series of modifications to the presented design is possible using the same set of equations as long as four free and independently variable section properties are maintained.

PROPERTIES OF RADIATION SHIELDING CONCRETE **60-17**

KAZUHISA SHIRAYAMA—Feb. 1963, pp. 261-280

Reports on a study of boron-containing aggregates from the United States and England and of seven heavy aggregates from Japan. Data are presented and discussed concerning mix proportions, workability, unit weight, strength, drying shrinkage, and absorption coefficients for gamma- and x-rays.

Based on data obtained for mix proportions, formulas for estimating the unit weight of concrete from the specific gravity of the aggregate are proposed.

The hematite ore used was found to be unsuitable for concrete aggregate because of an excessive amount of fines coating its surface. The tests indicated that, of the boron-containing material, the deleterious effects of colemanite on concrete strength and setting time is greater than that of borocalcite. This effect increases with increased fineness.

The barite concretes provided better shielding against x-rays than anticipated from density calculations. Barite or magnetite concretes were more suitable in shielding against gamma rays.

STRENGTH AND DEFLECTION OF CIRCULAR UNIFORMLY LOADED SLAB SUPPORTED BETWEEN CENTER AND PERIPHERY **60-18**

S. SERGEV and M. H. KASHANI-SABET—Feb. 1963, pp. 281-294

Formulas for principal bending moments and deflections are derived for a uniformly loaded circular slab, simply supported by a continuous circular support situated between the center and the periphery of the slab. The bending moments and deflections are found for different positions of the support, and for design purposes, these functions are plotted as ordinates and the location of the support as abscissas, both in nondimensional form. The construction is suitable for roofs of circular structures where an overhang is desirable.

The paper does not offer a new solution to the problem but attempts to present it in a suitable form for the designer. The paper is concluded by an example showing the use of the curves presented.

SOME ASPECTS OF CONCRETE SHELL BUCKLING **60-19**

RICHARD R. BRADSHAW—Mar. 1963, pp. 313-328

A review of the existing knowledge of buckling of shells. Note is taken of the lack of information concerned with concrete shells as against that available for plastic and metal shells. Reported work in metal and plastic shells in the areas of elastic, inelastic, and large deflection theory of buckling is applied to concrete shells.

Cylindrical shells are discussed under conditions of axial load, radial pressure load, torsional load, and bending. Spherical shells under radial pressure and curved plates under bending are also covered.

ABNORMAL CRACKING IN HIGHWAY STRUCTURES IN GEORGIA AND ALABAMA **60-20**

CALVIN C. OLESON—Mar. 1963, pp. 329-354

In 1947-1948, an investigation was made of abnormal cracking in concrete highway structures in Georgia and Alabama. Highway department records were searched for reliable data on cements and aggregates used in the construction. A preliminary analysis of the data indicated the possibility of alkali-aggregate reaction. Subsequent studies were made to determine probable average alkali contents of all cements included in the survey. It was found that three cements, all having average alkali contents of more than 0.6 percent, when used with natural siliceous aggregates from Montgomery, Ala., and allied sources, were involved in the cracking. A restriction of alkali in cements was imposed in 1947.

A continuing observation of the performance of approved cements in concrete in the two states has been in progress since the initial investigation. Visual observations, comprehensive soniscope tests, and precise measurement of length changes have been included in the studies. Extensive laboratory tests of aggregates have been undertaken.

FULL-SCALE PRETENSIONED FOLDED PLATES TEST-LOADED TO FAILURE **60-21**

J. I. GLANVILLE—Mar. 1963, pp. 355-370

Three full-scale pretensioned folded plate roof units were tested to collapse. One unit was made of normal structural concrete with straight prestressing strands, the second was of lightweight concrete with draped strands, and the third was also of lightweight concrete with draped strands. The test-loading in the case of the third unit was arranged to simulate, in addition to normal uniform loading, a 10-ton crane load near one support. The moduli of elasticity were obtained from the deflection under load. Ultimate moment, lateral stability of the free compression edges, diagonal tension, and punching-shear effects were observed. The theoretical analysis is not presented although the results of a theoretical analysis are given.

MATHEMATICAL ANALYSIS OF SHRINKAGE STRESSES IN A MODEL OF HARDENED CONCRETE **60-22**

THOMAS T. C. HSU—Mar. 1963, pp. 371-390

In an investigation, to be reported separately, it was found that micro-cracks exist at the interface between coarse aggregate and mortar in concrete before loading. To explain this fact, a model of hardened concrete was constructed consisting of rigid circular discs of aggregate, arranged in a square array and surrounded by mortar subjected to volume changes; these might be due to hydration, wetting and drying, or temperature change, etc. A numerical elastic stress analysis of this model by a point matching method showed that large tensile stresses exist at the interface between aggregate and mortar, when the clear distance between aggregate is small. It is believed that these tensile stresses cause the microcracks to appear.

EVALUATION AND LOCATION OF CRITICAL STRESSES IN PRETENSIONED STRUCTURES.....**60-23**

KALMAN CSIBI—Mar. 1963, pp. 391-432

Presents formulas which simplify the procedures for locating and evaluating stresses and moments and for locating hold-downs in pretensioned concrete structures. Topics covered include basic formulas and qualifications, formulas for building structures, formulas for bridge structures, and design of loading tables.

LIFT SLAB USED IN UNIVERSITY CONSTRUCTION.....**60-24**

GERMAN GURFINKEL—Apr. 1963, pp. 449-464

The analysis, design, and construction of a seven story building of the University of Havana are discussed with particular attention being given to the lifting process and connection details.

TENSILE BOND STRENGTH BETWEEN AGGREGATE AND CEMENT PASTE OR MORTAR.....**60-25**

THOMAS T. C. HSU and FLOYD O. SLATE—Apr. 1963, pp. 465-486

The tensile bond strength between four types of aggregate and cement paste or mortar was studied in about 1000 tests, and related to the tensile strength of the paste or mortar itself.

Direct tensile bond strength between aggregate and paste or mortar was found to be significantly less than the tensile strength of the paste or mortar, and dependent on rock type, surface roughness of aggregate, and water cement ratio.

The effects of age, moisture content of specimen during testing, and water-cement ratio on the difference between tensile and compressive strength of paste, mortar, and concrete have been investigated and are discussed. Also, an explanation for the effect of sand on the strength of mortar is given.

ANALYSIS OF LONG RECTANGULAR TANKS RESTING ON FLAT RIGID SUPPORTS..... ... **60-26**

J. D. DAVIES—Apr. 1963, pp. 487-500

The analysis of tanks resting on flat rigid supports is complicated by the nonlinear behavior of the base slab which is due to the change of support conditions with variations in loading. The partial loss of contact between the floor slab and the rigid support influences the magnitude of the bending moments developed in the tank. Since the principle of superposition is no longer valid the extent of this loss of contact cannot be determined directly.

The paper describes a method of analysis which employs a technique of successive corrections whereby the final bending moment distribution is determined accurately and rapidly after a few iterations.

TRENDS IN CONCRETE PAVEMENT DESIGN.....**60-27**

HARRY D. CASHELL—Apr. 1963, pp. 501-514

While there is a great deal of variety in the United States in the design of concrete highway pavements, there have been trends toward uniformity that can be noted. Among the items where a trend toward uniformity has been noticed are: subbase requirements, pavement cross sections, pavement types, slab lengths, and joining practices.

AUSTRALIAN EXPERIMENTS WITH FLAT PLATES.....**60-28**

FRANK A. BLAKEY—Apr. 1963, pp. 515-526

Describes three experimental flat plate structures erected and tested by the Commonwealth Scientific and Industrial Research Organization, Australia. Some of the more interesting results of the tests are presented.

INTERNATIONAL SERVICE.....**60-29**

RAYMOND C. REESE—May 1963, pp. 561-566

Retiring ACI President Raymond C. Reese—principal, Raymond C. Reese Associates, Toledo, Ohio—discusses ACI's role in unifying concrete research throughout the world so that results can quickly be translated into practical applications.

TESTING PROGRAM FOR LATERAL PRESSURE OF CONCRETE.....**60-30**

DAVID E. FLEMING and WILLIAM H. WOLF—May 1963, pp. 567-574

This paper is intended to implement the work "Pressures on Formwork" by ACI Committee 347 (622) published in 1957. Current formulas for lateral pressures of concrete are briefly discussed, and the means are offered whereby the formulas can be verified and improved.

X-RAYS FOR STUDY OF INTERNAL STRUCTURE AND MICROCRACKING OF CONCRETE.....**60-31**

FLOYD O. SLATE and STANLEY OLSEFSKI—May 1963, pp. 575-588

Use of x-radiography for studying the internal structure of concrete is described and discussed. Thin slices of concrete are sawed out of a mass and irradiated. Radiographs provide a permanent record for further study. Miscrocopic examination of stained specimens is used as a companion method and as a check.

Both methods revealed cracks formed during drying (and possible carbonation), almost exclusively at the interfaces between aggregate and mortar, predominantly on larger aggregates. These cracks were observed in concrete not subjected to any prior loading. In concrete subjected to large compression strains, bond cracking at the interfaces was observed to be greatly increased, with additional cracks through mortar bridging between bond cracks. Internal segregation of unhardened concrete is also observable (on the hardened concrete) by this technique.

The x-ray technique described is a powerful new tool for study of the internal structure, and changes in the internal structure, of concrete.

This paper is chiefly concerned with new experimental techniques. Systematic accounts of extensive findings made with these techniques have been presented in the JOURNAL by others at Cornell University.

TEST OF REINFORCED CONCRETE COLUMNS WITH HIGH SLENDERNESS RATIOS **60-32**

LUIS SAENZ and IGNACIO MARTIN—May 1963, pp. 589-616

Tests were made at the Materials Testing Laboratory of the University of Havana with 52 rectangular section concrete columns having longitudinal reinforcement with ties and flat ends with slenderness ratios varying from 21.6 to 43.0. The results of loads, stresses, and deformations are given and a Rankine type formula is developed based on these, to establish the relation between the strength of short columns and of columns with high slenderness ratios. Using this relation, another Rankine type formula is suggested for practical design of short, intermediate, and long columns. This formula is compared with formulas of the American Concrete Institute, British, German, and Russian codes.

PLANT DRYING AND CARBONATION OF CONCRETE BLOCK—NCMA-PCA COOPERATIVE PROGRAM **60-33**

HENRY T. TOENNIES and JOSEPH J. SHIDELER—May 1963, pp. 617-634

Previous studies have shown the effectiveness of treatment by carbon dioxide gas in improving the volume stability of concrete block and brick. Several products plants have installed equipment for drying and carbonation by combustion gases. An investigation was undertaken to evaluate various methods under plant operating conditions. The more effective treatments reduced greatly the potential shrinkage of the concrete units, while others were totally ineffective. Conclusions were reached regarding kiln conditions necessary for effective treatment.

The project was a cooperative one between the National Concrete Masonry Association, the Portland Cement Association, and five concrete products plants.

ULTIMATE STRENGTH BEHAVIOR STUDY BY REGRESSION ANALYSIS OF BEAM TEST DATA **60-34**

THEODORE C. ZSUTTY—May 1963, pp. 635-654

Regression analysis of ultimate moment test data is used to determine median prediction equations for the modes of moment tension and moment compression failure. The coefficient of variation of test results about the predicted values is small enough to indicate that the method and the selected mathematical form are able to produce equations which accurately represent the true behavior of the test data.

The equations for each failure mode are set equal to each other to determine equations for the balanced steel ratio and the balanced relative moment. The nearly constant value for the balanced relative moment agrees well with test beam behavior and is compared with present design procedure values.

The equation for moment tension failure is compared graphically with present design equations, and the resulting general agreement provides additional verification of the validity of the equations derived by both methods.

CONCRETE CONSTRUCTION FOR THE CENTURY 21 EXPOSITION **60-35**

(Eight-paper symposium)

HARLAN H. EDWARDS, JOHANN F. ENDERLEIN, ARTHUR R. ANDERSON, JOHN L. HUTSELL, M. PROCTOR, PETER H. HOSTMARK, JACK V. CHRISTIANSEN, and NORMAN G. JACOBSON, JR.—June 1963, pp. 673-718

A collection of seven brief papers describing highlights of the concrete construction employed at the 1962 Seattle World's Fair.

LOAD-BALANCING METHOD FOR DESIGN AND ANALYSIS OF PRESTRESSED CONCRETE STRUCTURES **60-36**

T. Y. LIN—June 1963, pp. 719-742

The concept of load balancing is introduced for prestressed concrete structures, as a third approach after the elastic stress and the ultimate strength methods of design and analysis. It is first applied to simple beams and cantilevers and then to continuous beams and rigid frames. Principles of load balancing for flat slabs, grid systems, and certain forms of shells and folded plates are introduced. The amount of loading to be balanced by prestressing is suggested. Accuracy and limitations of the method are discussed.

REPEATED LOADING EFFECT ON ULTIMATE STATIC STRENGTH OF CONCRETE BEAMS **60-37**

JOHN R. VERNA and THOMAS E. STELSON—June 1963, pp. 743-750

A group of 16 reinforced concrete beams were tested to determine the effect of history of prior loading on their ultimate static strength. All beams were identical except for reinforcing steel which was altered to obtain different modes of failure. The test results show significant increases in beam strength for a few thousand cycles of repeated load if the beam is not susceptible to bond failure. The load levels were such that many cycles (1,000,000 or more) would have caused a decrease in beam strength of about 40 to 55 percent. Bond failures showed no increase in strength and the most rapid deterioration in strength under cycles of load.

TENSILE STRENGTH OF CONCRETE **60-38**

D. J. McNEELY and S. D. LASH—June 1963, pp. 751-762

Reviews briefly the factors affecting the strength of concrete in tension and presents test results showing the effects of precompression, rate of loading, and variations of temperature on modulus of rupture. Precompression did not increase modulus of rupture, the rate of loading had a significant effect, rapid loadings gave apparently higher strengths, and low temperatures also lead to higher values for the modulus of rupture. A number of split cylinder tests were made and the results supported the view that this type of test is to be preferred to the modulus of rupture tests as a method of determining tensile strength.

ECONOMICAL DESIGN OF REINFORCED CONCRETE SLABS USING ULTIMATE STRENGTH THEORY **60-39**

ELIAHU TRAUM—June 1963, pp. 763-774

Presents a method, based on the concepts of ultimate strength design, for the economical design of slabs. Method considers the cost of the slab, subjected to a bending moment, as a function of the cost of concrete and reinforcing steel. The cost of formwork is considered a constant for any given depth of slab.

BEHAVIOR OF REINFORCED CONCRETE BEAMS WITH CLOSELY SPACED REINFORCEMENT **60-40**

JAMES P. ROMUALDI and GORDON B. BATSON—June 1963, pp. 775-790

Presents an extension to concrete of recent fracture arrest concepts in plastics and metals and in riveted stiffeners. At a reinforcement spacing less than some critical value, all cracks, it would appear, could be contained between adjacent reinforcing elements. Also presents a qualitative description of the mechanism involved and reports on a series of tests on beams with closely spaced wire reinforcement.

BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE (ACI 318-63).....**60-41**

Announcement of ACI standard

Separate copies of the standard available

ACI 318-63 supersedes Title Nos. 52-57, 59-7, 59-58

ACI COMMITTEE 318—July 1963, pp. 809-816

This Code provides minimum requirements for the design and construction of plain, reinforced or prestressed concrete, or composite structural elements of any structure erected under the requirements of the general building code of which this code forms a part. For special structures, such as arches, tanks, reservoirs, grain elevators, shells, domes, blast-resistant structures, and chimneys, the provisions of this Code shall govern so far as they are applicable.

This Code is written in such a form that it may be incorporated verbatim or adopted by reference in a general building code, and earlier editions of it have been widely used in this manner.

GUIDE TO PORTLAND CEMENT PLASTERING.....**60-42**

ACI COMMITTEE 524—July 1963, pp. 817-834

Recommendations for producing good interior and exterior portland cement plastering are described. Subjects covered are: important factors involved, materials, proportioning and mixing, sampling and testing, methods of application, bases, crack control, application and curing, and decorative finishes.

UNIQUE ROOF CONSTRUCTION AT DULLES AIRPORT.....**60-43**

JAMES B. LYTTLE—July 1963, pp. 835-852

Construction of the terminal building and tower for the Dulles International Airport serving Washington, D. C., is described. The roof of the terminal building, a special feature of this project, was constructed of precast lightweight concrete slabs on cables strung between the exterior supports. Two-foot beams were cast in place between bands of precast slabs when slabs and reinforcement were in place.

STRAINS AND STRESSES OF CONCRETE AT INITIATION OF CRACKING AND NEAR FAILURE.....**60-44**

M. F. KAPLAN—July 1963, pp. 853-880

Microcracking of concrete, in conventional short-time flexure, splitting, direct tension, and compression tests, was investigated using an electrical resistance strain gage technique. Cracking was found to occur at loads considerably less than those required to cause ultimate failure. Tensile stresses and strains, at cracking, depended on the volume of coarse aggregate in the mix; the greater this volume, the lower the stresses and strains.

The results suggest that the initiation of cracking may be more dependent on strain than on stress. Tensile and compressive stresses and strains, at or near ultimate failure, may also be affected by the volume of coarse aggregate. Strains at cracking and near ultimate failure were independent of the types of aggregate and water-cement ratios used; stresses were not. Tensile stresses and strains at or near ultimate failure depended on the method of test.

ANALYSIS AND DESIGN OF A CANTILEVER STAIRCASE.....**60-45**

PHILLIP L. GOULD—July 1963, pp. 881-900

The various factors influencing the behavior of a cantilever staircase are discussed and evaluated. Particular attention is given to the torsional moment at the intermediate landing and the support condition of the upper leg. A design example is presented illustrating those calculations that are peculiar to this type of structure.

CONTINUOUS DEFORMED BAR REINFORCEMENT FOR CONCRETE PAVEMENT.....**60-46**

MARTIN J. GUTZWILLER and JOSEPH L. WALING—July 1963, pp. 901-926

Results of laboratory experiments on simulated continuously reinforced concrete slabs are given. Specimens 3 x 28 ft were reinforced with deformed bars, variables being slab thickness, total percent of steel, position of steel, and subgrade modulus. The slabs were cast with preformed transverse cracks in the testing region. Vertical static loads simulated traffic loads and horizontal longitudinal loads were used to simulate stresses induced by temperature changes.

Results pertaining to slab deflections, crack widths, and stresses in reinforcement are emphasized. Criteria for optimum structural design of continuously reinforced pavements are reviewed.

METHOD OF PROPORTIONING NORMAL AND NO-FINES CONCRETE MIXTURES.....**60-47**

KRYSTIAN H. EYMAN—July 1963, pp. 927-944

Of the several methods of proportioning concrete, all aim at a selection of quantity as well as quality of component to obtain a predetermined concrete strength. A method is presented in this paper which selects quantity of components and predicts the degree of compaction so as to preserve both the condition of predetermined strength and weight of the concrete.

LOW PRESSURE STEAM CURING.....**60-48**

ACI COMMITTEE 517—Aug. 1963, pp. 953-986

This report discusses the purpose of steam curing and suggests that it is an economic expedient to facilitate form removal and early handling and use of the concrete product. It summarizes current knowledge of the effect of steam curing on the physical properties of concrete and describes the effect of each portion of the curing cycle. The effects of various components of the concrete, i.e., portland cement, aggregate, water, and admixtures are described. Recommended steam curing procedures for concrete block, concrete pipe, and structural elements are recorded. Equipment requirements are briefly summarized.

THE NEW MILLBANK TOWER, LONDON.....**60-49**

G. W. KIRKLAND—Aug. 1963, pp. 987-998

A description of the construction of a 34 story office building on the Thames. The building site is underlain with blue clay requiring extensive foundation investigation.

INVESTIGATION OF MULTI-PANEL REINFORCED CONCRETE FLOOR SLABS: DESIGN METHODS—THEIR EVOLUTION AND COMPARISON.....**60-50**

METE A. SOZEN and CHESTER P. SIESS—Aug. 1963, pp. 999-1028

This is the first of a number of reports to be published on an investigation of multiple-panel concrete floor slabs. The paper serves as an introduction to the later reports presenting the historical background of the design methods for floor slabs in ACI 318-56 and the over-all results of tests on five structures tested during the investigation.

VARIABLES IN CONCRETE AGGREGATES AND PORTLAND CEMENT PASTE WHICH INFLUENCE THE STRENGTH OF CONCRETE.....**60-51**

WILLIAM A. CORDON and H. ALDRIDGE GILLESPIE—Aug. 1963, pp. 1029-1052

Many researches and periodic articles during the past 40 years have not clearly established the validity of the relationship of water-cement ratio to strength presented by Abrams.

Interest in this subject was revived by recent articles by Walker and Bloem, and Gilkey summarized current thinking on the subject in 1961.

This study was undertaken not only to verify the findings of recent researchers, but to find explanations for the confusing, overlapping, and often opposing variables.

Sixty-nine concrete mixes made with wide variations in water-cement ratio and maximum size of aggregate are reported.

Strength theory postulations based on an analysis of Mohr's circles for concrete are advanced. An adaptation of a 300,000 lb universal testing machine for triaxial testing of concrete is explained along with test results obtained with this equipment.

It is possible to offer a reasonable explanation for conflicting test results and theory by analyzing the cohesion and angle of friction as related to combinations of paste failure, bond failure, and aggregate failure in concrete specimens.

ULTIMATE STRENGTH OF COLUMNS WITH BIAXIALLY ECCENTRIC LOADS.....**60-52**

JOHN L. MEEK—Aug. 1963, pp. 1053-1064

Studies rectangular columns loaded axially with bending moments about both principal axes. A theoretical contour line of the interaction surface for a particular column was calculated and compared with the contour line obtained experimentally. Tests of nine columns are reported with the theoretical results proving to be a good indication of column strengths. A method is suggested that may result in a satisfactory approximation to any interaction surface.

OPTIMUM DESIGN OF PRESTRESSED PLATES.....**60-53**

G. I. N. ROZVANY and A. J. K. HAMPSON—Aug. 1963, pp. 1065-1082

The recently introduced balanced load method is applied to plate design. Advantages of this method and deficiencies of conventional methods are discussed. Factors of economical design of prestressed two-way slabs and flat plates are investigated.

Two economical methods are introduced. In the first method the equation $\Delta z = q/S$ replaces the Lagrange equation ($\Delta\Delta z = q/D$). The other method is based on the minimum value of tendon volume. The economy of these methods is compared with other tendon patterns for usual types of two-way slabs and flat plates, and examples are worked out.

TALL CONCRETE BUILDING IN A REGION OF HIGH SEISMICITY.....**60-54**

RICHARD R. BRADSHAW—Sept. 1963, pp. 1097-1106

Describes the design and construction features of a 23-story concrete frame building built in San Diego, part of Seismic Zone 3, the highest intensity area in the United States. The building was approved before a 13-story restriction was adopted. An interesting feature is the use of columns twisted 60 deg between the seventh and eighth floors.

LABORATORY STUDY OF A 45-FOOT SQUARE FLAT PLATE STRUCTURE.....**60-55**

SIDNEY A. GURALNICK and ROBERT W. LAFRAUGH—Sept. 1963, pp. 1107-1186

Coordinated experimental and analytical studies of reinforced concrete floor systems were conducted at the University of Illinois and the Portland Cement Association laboratories for the purpose of providing a basis for more rational design methods than those now in use. Ultimately, it is expected that more economical floor systems will result from these improved design methods. The experimental program at the University of Illinois involved testing of one-quarter scale models of various floor systems.

To aid interpretation of the one-quarter scale model tests, a flat plate structure constructed at three-quarter scale and 45-ft square was tested at the PCA laboratories. The distribution of moments in the slab found in the tests at service load is compared with values for slab moments obtained by current design methods. Also, the observed behavior at ultimate strength is compared with values for ultimate load predicted by application of the yield-line theory and of a shear strength theory.

CHEMICAL PRESTRESSING OF CONCRETE ELEMENTS USING EXPANDED CEMENTS.....**60-56**

T. Y. LIN and ALEXANDER KLEIN—Sept. 1963, pp. 1187-1218

Self stressing, produced through the action of an expansive-cement component in concrete, was used to prestress high tensile strength steel in tension, thereby creating designed degrees of precompression in the concrete.

The so-called expansive cement consists of a blend of portland cement of high tricalcium silicate and low tricalcium aluminate content with an expansive component made by grinding a clinker of calcium alumino sulfate composition.

The concrete elements manufactured and tested, all self stressed by chemical prestressing, include four pressure pipes, three beams, a two-way reinforced slab, a one-way reinforced slab, and a hyperbolic paraboloid thin shell. Only the four pressure pipes and the two slabs are described in detail.

The behavior and the strength of pressure pipes and slabs determined by experiment are compared with analytical values based on conventional theory of elasticity and principles of prestressing. It is shown that experimental results obtained with chemical prestressing of pressure pipes and flat slabs agree closely with calculated theoretical values.

ULTIMATE STATIC AND IMPULSE LOADING OF REINFORCED CONCRETE BEAMS.....**60-57**

J. N. CERNICA and M. J. CHARIGNON—Sept. 1963, pp. 1219-1228

Forty-two reinforced concrete beams were used in this testing program. They were identical in size except for the percentage and grade of reinforcement. Thirty-six of the beams had only tensile reinforcement, the other six had two #4 bars in compression and two #5 bars in tension. Sixteen beams were tested to destruction under static load, the remaining 26 tested under impulse load. The load and reactions were recorded with a six-channel oscillograph and checked with a long-persistence-screen oscilloscope.

The results indicated that the beams reinforced with high strength steel slightly outperformed the intermediate and structural grades. The capacity of various beams to absorb energy is covered in the discussion of test results. None of the reinforcing steel failed by snapping.

SUGGESTED SPECIFICATIONS FOR STRUCTURAL CONCRETE FOR BUILDINGS **60-58**

ACI COMMITTEE 301—Oct. 1963, pp. 1321-1374

These specifications are a reference standard which the engineer or architect may make applicable to any building project by citing them in the project specifications. Individual chapters or sections cannot be copied into project specifications since their meanings will be changed by taking them out of context.

The specifications must be supplemented by designating or specifying individual project requirements. Four lists are provided listing places in these specifications and items that will require, or may require, specific treatment by the specification writer. The list of items requiring designation for specification are classed as: mandatory; additional mandatory, items designated or specified if the subject matter applies to the project; requirements at variance with these provisions; and requirements which are purely optional.

PRECAST FOLDED PLATES BECOME STANDARD PRODUCTS **60-59**

WALTER C. HARRY—Oct. 1963, pp. 1375-1388

Design, fabrication, and use of a precast folded plate roof unit is described. Originally designed for a single job, the units have found increased use and have become a standard product in Florida. Projects described include an elementary school with 50-ft spans, a residence with a 60-ft span, an airplane hangar with 120-ft spans, a church, and a wall for a baseball park 32 ft high.

STRUCTURAL BEHAVIOR OF CIRCULAR CONCRETE PIPE REINFORCED WITH WELDED WIRE FABRIC **60-60**

FRANK J. HEGER, EDWARD G. NAWY, and ROBERT B. SABA—Oct. 1963, pp. 1389-1414

Describes a three-edge bearing test program on 39 specimens with welded wire fabric reinforcing. The work program was part of an investigation to develop a rational procedure for the design of precast reinforced concrete pipe. Many test specimens were instrumented with SR-4 electric strain gages. In addition to strain measurements, recorded test data included sequence of crack formation, load versus vertical and horizontal deflections; load at 0.01-in. crack, ultimate strength, photographs of failure mode, and strength and stress-strain behavior of steel and concrete materials.

A summary of test results from three other test programs is also included.

MEMBRANE STRESSES OF PARABOLIC CONOID SHELLS **60-61**

RUDOLF ASCHENBRENNER—Oct. 1963, 1415-1428

The solution of membrane stresses in shells composed of conoidal surfaces is developed and evaluated for guide curves of both quadratic parabolic and semicubic parabolic form. The stress formulas are presented for dead, earthquake, and wind loadings.

EFFECTS OF AGGREGATE PROPERTIES ON STRENGTH OF CONCRETE **60-62**

DEIMAR L. BLOEM and RICHARD D. GAYNOR—Oct. 1963, pp. 1429-1456

Tests were made with 56 combinations of fine and coarse aggregate to study the effects of maximum size and other properties on water requirement and strength of concrete. Results confirm indications of earlier work that, at equal water-cement ratios, smaller sizes of aggregate produce higher concrete strengths than large ones. Depending on circumstances such as richness of mix, individual properties of the particular aggregate, and the magnitude of the size difference, an increase in maximum size may result in either an increase or decrease in concrete strength at a fixed cement content. Furthermore, other characteristics of the aggregate appear to account for much greater variations in strength than changes in size over the usual range. Particle shape and texture of both fine and coarse aggregate have a marked influence on concrete mixing water requirement, which in turn affects strength.

CIRCULARLY CURVED BEAMS TRANSVERSELY LOADED **60-63**

PANAYIOTIS J. SPYROPOULOS—Oct. 1963, pp. 1457-1470

Presents a general solution for the problem of horizontal circular beams loaded vertically with a concentrated load. A table provides values for bending moment, torsional moment, and shearing force at midspan for positions of the load at 15-deg intervals, curves with 30, 45, 60, 75, and 90 deg half-angles, and ratios of cross section dimensions of 1, 1.5, 2, 2.5, 3, and 4. By linear interpretation, any circular beam with angles of 60 to 180 deg and any concentrated or distributed, asymmetrical loading can be solved. A table showing the values for bending and torsional moment at midpoint for uniformly distributed loads is presented.

ADMIXTURES FOR CONCRETE **60-64**

ACI COMMITTEE 212—Nov. 1963, pp. 1481-1524

This third report of ACI Committee 212, Admixtures for Concrete, updates the previous reports of 1944 and 1954. In this report admixtures are classified in 15 groups according to type of materials constituting the admixtures, or to the characteristic effects of their use. Where an admixture possesses properties identifiable with more than one group it is discussed with the group that describes its most important effect on concrete. Types of admixtures discussed are: (1) accelerating; (2) water-reducing and set-controlling; (3) grouting, (4) air-entraining; (5) air-detraining; (6) gas-forming; (7) expansion-producing; (8) finely divided mineral; (9) damp-proofing and permeability-reducing; (10) bonding; (11) alkali-aggregate-expansion-reducing; (12) corrosion-inhibiting; (13) fungicidal, germicidal, and insecticidal; (14) flocculating; and (15) coloring. An extensive list of references is included.

PROPOSED ACI STANDARD RECOMMENDED PRACTICE FOR CONCRETE INSPECTION **60-65**

ACI COMMITTEE 311—Nov. 1963, pp. 1525-1534

This recommended practice sets forth standards and procedures relating to concrete construction which will serve as a guide to owners, architects, and engineers in planning their inspection program. The need for adequate inspection as a requirement for high quality, attractive appearing concrete at the least cost is emphasized.

INVESTIGATION AND REPAIR OF DAMAGE TO CONCRETE CAUSED BY FORMWORK AND FALSEWORK FIRE **60-66**

PETER SMITH—Nov. 1963, pp. 1535-1566

Describes what to look for and steps to be taken in investigating damage to concrete following a fire during construction. A selected list of references that can aid in assessing the significance of the damage is presented and discussed. A detailed account is given of an investigation of a fire on an arch bridge extension project where new concrete (6, 19, and 40 days old) and 20 year old concrete were damaged.

Repair and restoration measures and precautions to be taken to prevent fires, a special hazard of winter construction, are covered.

STRUCTURAL BEHAVIOR OR CIRCULAR REINFORCED CONCRETE PIPE—DEVELOPMENT OF THEORY **60-67**

FRANK J. HEGER—Nov. 1963, pp. 1567-1614

Develops general theoretical methods to evaluate cracking behavior, deflection, and ultimate strength of curved reinforced concrete flexural elements. Primary attention is directed toward development of rational methods for evaluating the structural behavior of circular reinforced concrete pipe under three-edge bearing loading. The methods are applicable for design of pipe in accordance with criteria established in ASTM C 76 and other specifications.

Methods developed for ultimate strength analysis or design of pipe are applicable with all types of reinforcing steel. The general method of investigation given for cracking and deformation analysis is valid with all types of reinforcing steel. Quantitative relations suggested for analysis of cracking and deformation behavior apply only to pipe reinforced with certain types of welded wire fabric reinforcing.

Cracking and ultimate strength results from 127 three-edge bearing tests on full-sized pipe are compared with calculated strengths and provide good corroboration of the theory in most cases. Where test results were used to obtain semiempirical constants in theoretical relations, other test results were available for checking.

STRENGTHENED CONCRETE **60-68**

FRITZ KRAMRISCH and PAUL ROGERS—Nov. 1963, pp. 1615-1620

The authors classify as "strengthened" that concrete which has less than specified minimum reinforcement thus distinguishing it from "plain" concrete and "reinforced" concrete. An approach to design is described for ground supported elements which introduces a straight-line transition between the stress, as a function of moment capacity, developed by the plain concrete and that produced by the minimum reinforcement using working stress deisgn. With this approach, amounts of reinforcing steel below the specified minimums are given credit for serving as a "strengthening" influence on plain concrete.

SHEAR STRENGTH OF PRESTRESSED BEAMS WITHOUT WEB REINFORCEMENT **60-69**

R. H. EVANS and E. G. SCHUMACHER—Nov. 1963, pp. 1621-1642

Tests to ultimate failure on 54 simply supported prestressed beams loaded with two symmetrically placed concentric loads are reported. Variables included: amount of longitudinal reinforcement, length of shear span, shape of cross section, and method of curing. A study was also made of the mechanism of failure by diagonal cracking. Distinction is made between beams failing in shear-compression, by diagonal cracking, and failures following diagonal cracking. Expressions are presented for the three modes of failure.

ACCURACY OF MODELS USED IN RESEARCH ON REINFORCED CONCRETE **60-70**

ZUHEIR Y. ALAMI and PHIL M. FERGUSON—Nov. 1963, pp. 1643-1664

Three series of beam models were tested to fail in diagonal tension, two series were tested with beams expected to fail in bond, and one series consisted of beams tested to fail in flexural compression. All specimens were loaded to failure.

Ultimate stresses at failure within each series were compared with the values predicted from model theory. The center deflections of the model beams, the compression strains, and the average distance between moment cracks were compared (in some series) with values predicted by model theory from the corresponding prototype.

Models failed to predict the behavior of their prototypes when bond was the primary or secondary reason for failure. When flexural compression or shear failure is expected, without complications from bond splitting, models with scales of 0.2 to 0.3 closely predict the prototype behavior. The smallest beam of each series consistently showed slightly higher strength.

Load-deflection and load-strain curves for prototypes can be predicted from models with scales as small as 0.334. Only approximate similitude of the average distance between moment cracks was obtained; differences of the order 2 to 27 percent were found.

GLOSSARY OF TERMS ON CEMENT AND CONCRETE TECHNOLOGY—Increment No. 5 ..... **60-71**

ACI COMMITTEE 116—Dec. 1963, pp. 1689-1696

As part of its mission, ACI Committee 116, Nomenclature presents the second published installment of a glossary of terms on cement and concrete technology. The glossary has been divided into 13 increments which are being presented to elicit discussion as they are completed, regardless of order. Following publication and discussion of the final installment, the committee will review and combine the groups for consideration as an ACI standard.

DEFLECTIONS OF PRESTRESSED CONCRETE MEMBERS **60-72**

SUBCOMMITTEE 5 of ACI COMMITTEE 435—Dec. 1963, pp. 1697-1728

This report discusses the factors affecting the short-time and long-time deflection behavior of prestressed concrete members. Analytical methods are presented for calculating these deflections taking into account prestress, transverse loading, creep, shrinkage, and relaxation of steel stress.

CONSTRUCTION LOADS ON SLABS WITH SHORED FORMWORK IN MULTISTORY BUILDINGS **60-73**

PAUL GRUNDY and A. KABAILA—Dec. 1963, pp. 1729-1738

Construction loads in a concrete structure where upper floors are shored from lower floors may exceed design service loads by an appreciable amount. A method for determining these erection loads is presented for flat slab or flat plate construction. The effect of shoring different numbers of floors and the effect of construction loads on design are also discussed.

PRELIMINARY STUDY OF THE EFFECTS OF WATER-REDUCING RETARDERS ON THE STRENGTH, AIR VOID CHARACTERISTICS, AND DURABILITY OF CONCRETE **60-74**

THOMAS D. LARSON, JOHN L. MANGUSI and RAYMOND R. RADOMSKI—Dec. 1963, pp. 1739-1754

Concretes made with water-reducing retarders showed improved freeze-thaw durability, primarily as a result of increased strength. Specimens made from constant slump, constant cement factor mixtures containing several agents at various dosage levels had higher flexural and compressive strengths than the control specimens. Flexural strengths at 7 and 28 days correlated significantly with durability factor.

Microscopic studies indicated that there were minor differences between the air void systems of control and test concretes. In particular, spacing factors increased with retardation. This appeared to result from air entrainment by the water-reducing retarders and from bubble dissolution.

V.61 SYNOPSES

Institute papers and reports of Proceedings V. 61 (January-December 1964 ACI JOURNAL)

REVIEW OF CODE REQUIREMENTS FOR TORSION DESIGN 61-1

Gordon P. Fisher and Paul Zia—Jan. 1964, pp. 1-44

Twenty-two specification documents from various counties are reviewed with reference to torsion design. Sixteen of these documents are found to specify design requirements concerned with torsion. These design specifications are compared in terms of torsional stress calculations, allowable torsional shear stresses, and torsional reinforcement. Numerical examples are given to illustrate the various design procedures. Appended are English translations of excerpts dealing with torsion, taken from reinforced concrete design codes of various countries.

TABLES FOR CONCRETE MIX PROPORTIONING 61-2

Sandor Popovics—Jan. 1964, pp. 45-56

Existing methods of selecting proportions for concrete usually offer tabulated values as guides in approaching the optimum amount of water, cement, and aggregates. For more accurate estimates, tables are presented in this paper which were developed recently for the State Highway Department of Alabama.

One of these tables refers to the adjustments in water content for slump. In other tables, cement factors, in bags per cubic yard, are presented as a function of mix proportion, grading, and average specific gravity of mineral aggregate.

Further tables are offered to obtain the average specific gravity of mineral aggregate when a mixture of two materials of different specific gravities is used. Numerical examples illustrate the use of the tables presented. While these tables are not a self-sufficient method of concrete mix proportioning, they will reduce the number of trial mixtures required.

STRENGTH OF THE COMPRESSION SLAB OF T-BEAMS SUBJECT TO SIMPLE BENDING 61-3

Gottfried Brendel—Jan. 1964, pp. 57-76

The reports of Comite Europeen du Beton (CEB) Committee 9, T-Beams, are summarized. Refined criteria are developed from known theoretical solutions of effective width of T-beams and compared with test results and code requirements of various countries.

RAPID FIELD ASSESSMENT OF STRENGTH OF CONCRETE BY ACCELERATED CURING AND SCHMIDT REBOUND HAMMER 61-4

C. A. P. Boundy and G. Hondros—Jan. 1964, pp. 77-84

Tests were made on 6-in. cubes from 17 different batches of concrete. Some of the cubes were cured in water and tested in a standard compression machine. The remaining cubes were stream cured and tested with the rebound hammer prior to being loaded to failure in a compression testing machine.

The results suggest that the rebound hammer may be used in conjunction with some method of accelerated curing to provide a rapid and convenient field method for estimating the strength and quality of concrete.

HELICOIDAL STAIRCASE STUDY 61-5

A. R. Cusens and Supachai Trirojna—Jan. 1964, pp. 85-102

Methods of analysis for a projected fixed-ended reinforced 80 deg helicoidal staircase are compared. The methods used are those of Holmes, Scordelis, Morgan, and Bergman.

Tests are described on half-scale models under uniformly distributed loading. For a model based on the prototype design a load factor in excess of 4.8 was obtained. When reinforcement against lateral moment was reduced by 50 percent, together with some reduction to main steel, the load factor was 3.6.

The use of ultimate strength design based on vertical moments only gave a simple and safe solution for the staircase under study. Proposals for further work in this field are made.

A GUIDE FOR DETERMINATION OF BOND STRENGTH IN BEAM SPECIMENS . . . 61-6

ACI Committee 408—Feb. 1964, pp. 129-136

This report of ACI Committee 408, Bond Stress, was prepared to serve as a guide for the design of bond test beams and the choice of test procedures suitable for the determination of bond values of reinforcing bars. Although the Institute Standard ACI 208-58, specifies in complete detail the beam specimens and the test procedures to determine the relative bond values of reinforcing bars, it limits the bars to one size, concrete to one strength and the embedment length to a maximum of 16 in. The guide is intended to provide greater flexibility in the recommended test specimen and test procedure to permit the use of bars of different diameters, more than one strength of concrete, and longer embedment lengths needed to develop high yield strengths of modern deformed bars. The methods of support and measurement of slip are also different from those in ACI 208-58.

PHOENIX AIRPORT TERMINAL BUILDING—A PRESTRESSED CHALLENGE 61-7

Walter E. Riley—Feb. 1964, pp. 137-150

The new Phoenix Municipal Airport Terminal roof consists of twenty-two 8 ft wide prestressed T-beams 152 ft long supported on cast-in-place concrete girders. The T-beams have a clear span of 84 ft and cantilever at each end, 34 ft.

It was desired to expose the end of the T-beams and to limit the depth to 3 ft. This results in a shallow beam having a depth to span ratio of 1/28. A combination pretensioned and post-tensioned design was approved for the building, subject to testing for deflection control.

Prestressed tees with long overhangs may be safely analyzed for strength using theoretical mechanics; however, only instantaneous deflections can be calculated accurately. Long-time deflections should be predicted by load testing.

Deflection analysis, load tests, and field deflections are discussed.

Gilbert R. Williamson—Feb. 1964, pp. 151-154

The standard procedure for making concrete test cylinders tends to bring water to the top of the cylinder. Presents experimental results to show that standard 6 × 12 in. concrete cylinders are not of uniform strength and that the top one-third is the weakest part.

Joseph B. Yesselman—Feb. 1964, pp. 155-170

The method consists in basing the distribution of total panel moments between column and middle strips on the rectangularity of the panel in a manner analogous to that followed in the design of two-way slabs. By this procedure, in long, narrow panels, the two-way plate action effects disappear and the slab approaches a one-way slab. Conversely, in more nearly square panels, the results obtained conformed closely to the empirical design method.

D. A. Hausmann—Feb. 1964, pp. 171-188

The protective mechanism by which concrete prevents the corrosion of encased steel is reviewed. The effects of impressed voltages on the concrete-steel system are described and related to chemical reactions occurring at the steel surface. An important distinction is made between the ohmic resistance of concrete and the "apparent" resistance offered by polarization effects which control both current collection and discharge over a wide range of operating potentials. Criteria are suggested for the practical application of cathodic protection to reinforced concrete structures. A cathodic protection experiment with mortar-lined-coated steel pipe is reported.

Chesman A. Lee—Feb. 1964, pp. 189-194

Discusses the design assumptions for determining the size of the foundation bolts for a heavy drive. Presents simple calculations for finding the moment of resistance, the tensions in the bolts, and the pressure on the concrete.

B. P. Sinha, Kurt H. Gerstle and Leonard G. Tulin—Feb. 1964, pp. 195-212

An experimental investigation into the behavior of plain concrete under cyclic loading is described. Stress-strain curves obtained for concrete cylinders under such loading are presented, and analytical stress-strain relations for cyclic loading are derived.

Assuming the property of uniqueness of stress-strain relations, it is shown how the cyclic stress-strain curves can be used to predict the behavior of a concrete fiber subjected to an arbitrary load history (neglecting creep).

Dan E. Branson—Feb. 1964, pp. 213-230

The effects of direct shrinkage and creep deformation and differential shrinkage in composite concrete beams are discussed. Two different methods for determining differential shrinkage stresses and deflections are briefly summarized and compared. Procedures for predicting the total (initial plus time-dependent) deflection of shored and unshored composite beams, in which the precast beams are either reinforced or prestressed, are discussed. Also included is a discussion of existing experimental data dealing with the time-dependent behavior of composite concrete beams.

Panayiotis J. Spyropoulos—Feb. 1964, pp. 231-238

For architectural reasons, columns are frequently omitted at corners of buildings. To support the loads, spandrel beams are cantilevered and rigidly connected at their intersections. Because of the rigidity of connections, both cantilevers are subject to bending and torsion.

Torsional moments are troublesome and difficult to handle. Special precautions must be used, both in the design of these beams and in proper placement of reinforcing steel.

This study presents an analysis of two right angle cantilever beams under varying load conditions. For ease in determining the bending and torsional moments at the end of cantilevers, a table of values is included.

Valeriu Petcu—Feb. 1964, pp. 239-244

Uses the finite differences method for determining deflections in beams of variable stiffness. A worked example using this method compares favorably with the same example solved previously by Maclaurin's series.

Richard R. Bradshaw—Mar. 1964, pp. 257-264

Describes the construction of a corrugated toroid shell roof for an ice skating rink. The geometry of the vault is discussed. Also the problems of precasting the double-curved concrete pieces on top of one another are investigated and the solutions to these problems are shown. The difficulties which arose during the erection and avoidance of these difficulties in the future are discussed. The economics of this system are noted.

F. W. Sims, James A. Rhodes and Ray W. Clough—Mar. 1964, pp. 265-286

The development and detection of major transverse cracks in a mass concrete gravity dam is traced from the construction period through several years of project operation. Methods for determining the extent and size of a principal crack in one block are described.

The results of structural behavior instrumentation observations showed the crack widths have not changed substantially, that the structure exhibits an elastic response to live loads and temperature variations, and that there has been no apparent change in the stability of the structure during the past 10 years.

Application of the finite element method in the theoretical stress and displacement analysis of a cracked and uncracked gravity dam section is described. Results show stress concentrations of the order of 500 psi for the most unfavorable conditions of loading and specific crack height, and that only a moderate increase in maximum stress, to about 600 psi, will exist even when no limits are imposed on crack height.

Norfork Dam is considered to be safe, with a single transverse crack existing in most spillway monoliths, under normal loading conditions which may be expected. Provisions are being made to limit adverse hydrostatic pressures beneath and within the structure.

STRENGTH OF CONCRETE TEST CYLINDERS CAST IN WAXED PAPER MOLDS 61-18

A. R. Cusens—Mar. 1964, pp. 287-292

Confirms that the strengths of capped concrete test cylinders cast in waxed paper molds are less than those made in metal molds with identical procedures. Shows that the major differences in strength is attributed to the higher density of the cylinders cast in metal molds. Suggests that a heavier reusable base plate might be used with waxed paper molds.

BIAXIAL ECCENTRICITIES IN ULTIMATE LOAD DESIGN 61-19

A. Aas-Jakobsen—Mar. 1964, pp. 293-316

Describes a design method for short, reinforced concrete columns subjected to axial load and biaxial bending. The method is based on the ACI Building Code (ACI 318-63) and constant stress distribution. The method is also based on the assumptions that (1) the carrying capacity of a section is equal to the algebraic sum of the carrying capacities of the concrete and reinforcement at compression failure; (2) a stepwise constant stress distribution is used; and (3) when the edge stress of the concrete is fully employed, the stress in the reinforcing steel is also fully employed.

DYNAMIC TESTS OF REINFORCED CONCRETE COLUMNS 61-20

Kenneth F. Reinschmidt, Robert J. Hansen and Cheng Y. Yang—Mar. 1964, pp. 317-334

Static and dynamic tests to failure were performed on 205 reinforced and plain concrete columns with slenderness ratios (L/t) from 3 to 25, under concentric and eccentric loads.

In general, the results of these tests compare well with the ACI column formulas, except for very long columns ($L/t = 25$), if the static strengths of concrete and steel are replaced by corresponding dynamic strengths which depend on the rate of loading. The results indicate that, for loads similar to those obtained experimentally, the dynamic columns are about 30 to 40 percent stronger than corresponding columns loaded statically, and that the effects of all inertial forces are negligible, except for very slender ($L/t = 25$) columns, which are 70 to 100 percent stronger when tested dynamically than when tested statically.

INCREASING TENSILE STRENGTH OF TERRAZZO 61-21

A. M. Neville—Mar. 1964, pp. 335-344

Results of tests on terrazzo as normally used and with the addition of glass fiber or asbestos fiber are presented. It is shown that glass fiber improves the early strength of terrazzo made with a moderately rapid hardening cement.

EQUATION FOR THE STRESS-STRAIN CURVE OF CONCRETE 61-22

Prakash Desayi and S. Krishnan—Mar. 1964, pp. 345-350

A simple equation is proposed for the stress-strain curve of concrete in compression. The equation is found to represent it well not only up to the maximum stress but also beyond, and may conveniently be adopted in the computation of ultimate resisting moment of reinforced concrete sections.

ON THE FORMULA FOR SPIRAL REINFORCEMENT 61-23

Ti Huang—Mar. 1964, pp. 351-354

Discusses the ACI Building Code formula for finding the minimum amount of spiral reinforcement in short columns. Suggests a modification of the formula based on data obtained from triaxial tests of concrete.

TESTS FOR PRECAST WALL PANELS . . 61-24

Subcommittee V, ACI Committee 533—Apr. 1964, pp. 369-382

This report is submitted for discussion prior to preparing a recommended practice. Emphasis is placed on those specification and production control tests and procedures which have led to confusion among architects, engineers, prefabricators, and owners. Tests for compressive strength and for freeze-thaw durability are discussed. Standard 6 × 12-in. cylinders are recommended for compressive strength samples wherever such procedure is practical. Otherwise, 4-in. cubes are suggested, the test results of which should be reduced 20 percent as an estimate of cylinder strength. Due to the vertical orientation of most wall panels, specification of freeze-thaw testing is not recommended generally. The report recommends that wall panel concretes should be air entrained without specification of a fixed percentage of air content. A preliminary list of needed research is included.

PREFABRICATED BUILDING MADE OF TRIANGULAR PRESTRESSED COMPONENTS 61-25

Zenon A. Zielinski—Apr. 1964, pp. 383-398

Describes a factory building in Warsaw, Poland, where the basic structural element is a precast unit in the shape of an equilateral triangle. The unit was used for both floors and walls. While the building was designed to be prefabricated, it presents all the advantages of a monolithic structure.

ULTIMATE STRENGTH WITH HIGH STRENGTH REINFORCING STEEL WITH AN INDEFINITE YIELD POINT 61-26

Nripendra C. Sinha and Phil M. Ferguson—Apr. 1964, pp. 399-418

Ultimate strength analysis for concrete members reinforced with high strength steel having an indefinite yield point has been used on Bernoulli's hypothesis, the absence of slip between concrete and steel, and on assumed ultimate concrete strain ϵ_{cu}. Interaction diagrams for eccentrically loaded columns have been plotted based on one such high strength steel.

The moment capacities of eccentrically loaded symmetrical columns reinforced with total steel providing $p = p'$ of 2.5 or 4.0 percent were found to increase gradually with increasing eccentricity to an absolute maximum value of moment for $e = \infty$.

Detail strain measurements showed that short-time load capacity was not reached until the compressive strain reached 0.0050 to 0.0060 and the rotation angle of a 1-in. element reached a minimum of 3600×10^{-6} radians for beams 6-in. deep or 840×10^{-6} radians per in. for a column 9 in. deep (eccentricity = 10.62 in.).

ECONOMIC ASPECTS IN THE DESIGN OF SOME REINFORCED CONCRETE STRUCTURAL MEMBERS 61-27

Dudley G. Norman—Apr. 1964, pp. 419-440

A relationship is expressed between the strength of concrete mixes and their cost, in terms of unit costs of the materials used in them. Expressions are then derived for the optimum dimensions of one-way slabs, two-way slabs, rectangular slabs, T-beams, and ribbed slabs, when subject to bending. Expressions are also derived for the cost of tied columns subjected to shear force. The cost of forming and of nominal reinforcement (for example, temperature steel) are considered.

Both the British Standards and the ACI Code are used and, wherever appropriate, separate expressions are derived for each code of practice. The load factor methods of these codes are used when considering flexure and concentric thrust.

THE RIDDLE OF SHEAR FAILURE AND ITS SOLUTION 61-28

G. N. J. Kani—Apr. 1964, pp. 441-468

This paper intends to answer two questions: (a) What is the internal mechanism of the so-called shear failure of a reinforced beam, and (b) What is the strength of this mechanism?

Under increasing load a reinforced concrete beam transforms into a comb-like structure. In the tensile zone the flexural cracks create more or less vertical concrete teeth, while the compressive zone represents the backbone of the concrete comb. The analysis of this structural system has revealed that two rather different mechanisms are possible: as long as the capacity of the concrete teeth is not exceeded the beam-like behavior governs; after the resistance of the concrete teeth has been destroyed a tied arch, having quite different properties, remains.

For both mechanisms simple analytical expressions have been developed. Tests carried out at the University of Toronto on several series of reinforced concrete beams have confirmed this theory, as did some other available test results.

RESPONSIBILITY IN CONCRETE 61-29

Roger H. Corbetta—May 1964, pp. 481-486

Stresses the important role that ACI can play to insure greater quality workmanship in concrete construction. Suggests that a governing body be established with the authority to issue and revoke certificates of competency among contractors, concrete suppliers, and testing laboratories.

GLOSSARY OF TERMS ON CEMENT AND CONCRETE TECHNOLOGY-INCREMENTS NO. 2, 3, AND 4 61-30

ACI Committee 116—May 1964, pp. 487-508

As part of its mission, ACI Committee 116, Nomenclature, presents the third published installment of a glossary of terms on cement and concrete technology. The glossary has been divided into 13 increments which are being presented to elicit discussion as they are completed, regardless or order. Following publication and discussion of the final installment, the committee will review and combine the groups for consideration as an ACI standard.

CONSTRUCTION OF BUTTRESSED DOME SEGMENT 61-31

Andrew R. Nasser—May 1964, pp. 509-520

Presents the construction phase of the Culver City High School Auditorium in southern California. Provides a general description of the structure but is principally a descriptive record of the construction operations.

INFLUENCE OF TIES ON THE BEHAVIOR OF REINFORCED CONCRETE COLUMNS . . 61-32

James F. Pfister—May 1964, pp. 521-538

To aid development of the 1963 ACI Building Code, 11 rectangular tied columns were tested under concentric load to explore the influence of arrangement and spacing of lateral ties on the strength and behavior of tied columns. In three of the columns, full ties were provided as required by the 1956 Code, and in another three columns only exterior ties were used. Two columns had ties only at the ends and at midheight of the columns, and three columns were provided with ties only at their ends.

It was found that the primary function of the ties was to restrain the concrete laterally so that it could develop its full strength in a gradual type of compression failure. Exterior ties surrounding the longitudinal reinforcement were found to be as effective as combined interior and exterior ties conforming to the 1956 Code. It is concluded that the new tie requirements of the 1963 Code should be entirely adequate.

COMPUTER ANALYSIS OF CYLINDRICAL SHELLS 61-33

A. C. Scordelis and K. S. Lo—May 1964, pp. 539-562

A computer program, written for the IBM 7090 computer, is described which determines the internal forces, displacements, and reactions in a simply supported, multiple-cylindrical shell subjected to a set of known loads and boundary conditions. The structure analyzed may consist of up to 25 circular shell segments joined along their longitudinal edges.

The program uses a direct stiffness solution in matrix form to analyze the multiple shell system and the formulation is based on the Donnell-Jenkins shell equation.

Results obtained using the computer program are presented and used to discuss the effect of a number of variables in the design of multiple cylindrical shells.

THE RESTRAINED LONG CONCRETE COLUMN AS A PART OF A RECTANGULAR FRAME* **61-34**

John E. Breen and Phil M. Ferguson—May 1964, pp. 563-588

This investigation was concerned with the long tied column as part of a building frame. The column was directly loaded axially while a beam supplied a moment loading in such a manner that the far end of the column was restrained against rotation, but was not completely fixed. Short-time loading to failure was used for five frames. A single test under 90 day sustained load followed by loading to failure was included.

At a nominal eccentricity of 0.3 of the column thickness, there was no long column strength reduction.

At an eccentricity of 0.1 of the column thickness there was no long column strength reduction at an h/t of 15 but at an h/t of 30 there was a 3 percent reduction for one specimen and 8 percent for another.

The longer columns were considerably relieved of their moment loading by virtue of their reduced stiffness at higher loads. The shorter columns were greatly shielded by compression hinging at their loaded end.

STRESSES IN END BLOCKS OF A POST-TENSIONED PRESTRESSED BEAM **61-35**

Ti Huang—May 1964, pp. 589-602

The stresses in the end blocks of a post-tensioned prestressed concrete beam were studied by actual measurement with SR-4 strain gages, as well as by numerical analysis. The results were then compared with the computed values by the methods of Magnel and Guyon. Although no general conclusion was attempted, it was apparent from this study that both existing methods may be considerably in error in the estimation of critical vertical stress. It was also found that the vertical tensile stress is higher in an end block with a length-depth ratio of 1.5 than in a block with a ratio of 1, and that a critical tensile zone exists near the interior of the end block, if the beam body is of I, T, or box shape.

CHECK LIST FOR BATCH PLANT INSPECTION **61-36**

Lyman S. Bray and Oswin Keifer, Jr.—June 1964, pp. 625-642

The detailed check list presented was developed for use by concrete inspectors. The check list, when properly used, will familiarize the inspector with the batch plant, will indicate any items not complying with the specifications, and will indicate items not considered sound batching and mixing procedures. The check list is comprehensive to provide for the many variables encountered in batching and mixing plants and will not apply in its entirety to any particular plant. The major uses of the check list and the contributions to the quality control of concrete production are: (1) Determination of specification compliance of a concrete batching and mixing plant prior to start of operations; (2) Evaluation of a concrete plant and its operation; and (3) Familiarization of a concrete inspector with the batching plant and its operation; and (4) Assistance in training concrete inspectors for batch plant operations.

SHEAR STRENGTH OF REINFORCED STRUCTURAL LIGHTWEIGHT AGGREGATE CONCRETE SLABS **61-37**

Eivind Hognestad, Richard C. Elstner and J. A. Hanson—June 1964, pp. 643-656

To aid development of the 1963 ACI Building Code, six lightweight concrete slabs were tested to explore the shear strength of slabs made with structural lightweight aggregate concrete as compared to similar slabs made with normal weight concrete. This limited investigation indicated that the shear strength of lightweight slabs is characterized by the splitting tensile strength of the concrete rather than by compressive strength. This conclusion is reinforced by previous findings regarding the shear strength of lightweight beams. The derivation of the 1963 ACI Code provisions for the shear strength of lightweight aggregate concrete slabs is explained and substantiated by the test findings.

TENSILE STRENGTH OF CONCRETE AFFECTED BY UNIFORMLY DISTRIBUTED AND CLOSELY SPACED SHORT LENGTHS OF WIRE REINFORCEMENT **61-38**

James P. Romualdi and James A. Mandel—June 1964, pp. 657-672

Fracture arrest concepts applied to closely spaced wire reinforced concrete have revealed that tensile stress is proportional to the inverse square root of wire spacing. Previous theoretical and experimental studies have demonstrated this for the case of continuous wires arranged parallel to one another and parallel to the direction of major principal stress. Similar results may be achieved with short lengths of wire in random orientation but nearly uniform spacing throughout the concrete. A correction factor must be considered to account for the fact that some portion of the wires are not properly oriented for effective crack control. The crack arrest mechanism is demonstrated for beam and indirect tension (splitting) specimens.

CHIMNEY FOUNDATIONS **61-39**

John W. Smith and Max Zar—June 1964, pp. 673-700

A method is described for designing chimney foundations for various loading conditions with the help of circular slab theory. Pile foundations are included. Charts are presented for facilitating the analysis. An example is given for a footing on soil.

BEHAVIOR OF CONCRETE COLUMNS REINFORCED WITH HIGH STRENGTH STEELS* **61-40**

Claudio E. Todeschini, Albert C. Bianchini and Clyde E. Kesler—June 1964, pp. 701-716

The use of high strength steels in reinforced concrete columns was investigated by conducting parallel theoretical and experimental studies. The results of the experimental work are given and the behavior of the specimens under load described. A brief outline of the theoretical analysis is presented together with a list of the assumptions made. Discussion of the results and comparison between theoretical and experimental values are made with special empahsis on the effect of eccentricity of loading, concrete strength and percentage of reinforcement.

The fuller utilization of the strength capacity of the high strength steels is discussed in the light of the conclusions drawn from the investigation and a comparison is made with the requirements of the current Building Code (ACI 318-63).

APPROXIMATE ANALYSIS OF SHEAR WALLS SUBJECT TO LATERAL LOADS 61-41

Riko Rosman—June 1964, pp. 717-734

Presents a simple, approximate analysis for various types of shear walls widely used in present engineering practice.

The continuous sytem method is used and the integral shear forces in the continuous connections of individual piers are chosen as the statically redundant functions. Deformations due to bending moment, the contribution of normal forces in the piers, and shear forces in the connecting beams are taken into account.

Deals primarily with the problem of a concentrated lateral load at the top of the wall; formulas for a distributed loading are given, but without derivation.

RECOMMENDED PRACTICE FOR CONCRETE INSPECTION (ACI 311-64) 61-42

Announcement of ACI standard

Separate copies of the standard available

ACI 311-64 supersedes Title No. 60-65

ACI Committee 311—July 1964, p. 753

This recommended practice sets forth standards and procedures relating to concrete construction which will serve as a guide to owners, architects, and engineers in planning their inspection program. The need for adequate inspection as a requirement for high quality, attractive appearing concrete at the least cost is emphasized.

SLIP FORMING NEW YORK STATE WORLD'S FAIR PAVILION 61-43

Maurice Madison—July 1964, pp. 755-762

The New York State Pavilion at the 1964-1965 World's Fair in New York consists of two primary elements. The main exhibit structure which features 16 monolithic columns supporting a suspended roof of multicolored plastic. In conjunction with the exhibit structure are three concrete observation towers of 100, 180, and 230-ft heights. The columns and observation tower structures were erected by the slipform method. The construction procedure for these elements is described.

LOAD-MOMENT-CURVATURE CHARACTERISTICS OF REINFORCED CONCRETE CROSS SECTIONS 61-44

E. O. Pfrang, C. P. Siess and M. A. Sozen—July 1964, pp. 763-778

Presents a method for the development, in a usable form, of data relating axial load, moment and curvature for reinforced concrete cross sections. The method is such that it does not require extensive simplifying assumptions concerning the stress-strain relationship for the concrete and the reinforcement.

The method is applied to several cross sections, and information is presented and discussed concerning the relationship between axial load, moment, and curvature. The effect of several cross-sectional parameters on this relationship is also discussed.

REPLACEMENT OF LIGHTWEIGHT AGGREGATE FINES WITH NATURAL SAND IN STRUCTURAL CONCRETE 61-45

J. A. Hanson—July 1964, pp. 779-794

Reports an investigation of the effect of replacing the fines of four particular structural lightweight aggregates with equal volumes of natural sand. Cement contents were varied to obtain compressive strengths over the range of 3000 to 6000 psi. A comparison of the reported physical properties for lightweight concrete was provided by tests of normal weight concrete of corresponding compressive strength.

The test results are presented for each of the lightweight aggregates, showing the mix and physical properties, as functions of the partial or complete fine aggregate replacement, for concretes at compressive strength levels of 3000, 4000, 5000, and 6000 psi.

In general, the structural properties were improved as the amount of natural sand was increased, but this improvement was achieved only with considerable increase in the unit weight. Decrease of total water and cement contents required for a given slump and compressive strength were greater for the harsher crushed aggregates.

STRESSES IN POINT SUPPORTED COMPOSITE WALLS 61-46

Saki Rosenhaupt—July 1964, pp. 795-810

Based on a proposed general elastic theory of composite walls, the particular case of masonry walls with reinforced concrete foundation beams acting as tension ties is studied, numerical examples solved for different wall-beam rigidity ratios, and conclusions derived as to the use of simplifying assumptions.

DURABILITY AND BEHAVIOR OF PRETENSIONED BEAMS 61-47

Edwin C. Roshore—July 1964, pp. 811-846

To develop data on the factors affecting the durability of pretensioned concrete beams, 28 large beams containing pretensioning strands and 412 small companion specimens without pretnsioning strands were fabricated. The concrete in 22 of the beams was air-entrained; that in the other six was not. An appendix presents computations used in designing the beams.

Some of the beams were subjected to laboratory tests, which indicated that the air-entrained beams showed less average camber and less midspan deflection, but the non-air-entrained beams withstood greater average flexural loads. A number of the auxiliary specimens were also tested in the laboratory to determine the strength, elastic, and plastic properties of the concrete.

Some specimens were exposed to natural weathering. A few early results are noted.

FREE-STANDING STAIRS 61-48

Franz Sauter—July 1964, pp. 847-870

A direct method for analyzing free-standing stairs with equal upper and lower runs and without landing support is presented for a symmetric loading case. The method is based on Fuchsteiner's simplification of the stair structure into a space frame composed of linear bar elements. Deformations are calculated from the work integral with the application of the principle of least work; and redundants are determined by solving the elastic equations. Selection of a proper

statically determinate system allows a direct approach and obviates the tedious calculation of unknown moments by superposing different supporting conditions. This selection also allows consideration of both cases of fixed and simple support conditions at the upper and lower floor levels. Introducing two minor simplifications, the method is further developed to include worked-out formulas for the redundants, and design charts are presented which permit the direct reading of coefficients for the calculation of the unknown moments as a function of the geometric properties of the stair and for different loading conditions. The calculation of an otherwise highly complex structure is reduced to a minimum as shown in an example.

RATE OF LOADING EFFECT ON MOMENT-CURVATURE RELATION IN PRESTRESSED CONCRETE BEAMS 61-49

I. O. Oladapo—July 1964, pp. 871-888

Describes experiments to investigate the effect of the rate of loading on the moment-curvature relation of prestressee concrete beams. It was found that the relation is dependent on the rate of loading, the steel ratio, and on the ratio of the effective depth to the over-all depth of the beam. The ultimate moments of under-reinforced sections tend to increase with increase in the rate of loading. In the case of over-reinforced sections, it seems that there is a rate of loading at which the ultimate moment is a minimum.

GLOSSARY OF TERMS ON CEMENT AND CONCRETE TECHNOLOGY—INCREMENT NO. 6. 61-50

ACI Committee 116—Aug. 1964, pp. 913-920

As part of its mission, ACI Committee 116, Nomenclature, presents the fourth published installment of a glossary of terms on cement and concrete technology. The glossary has been divided into 13 increments which are being presented to elicit discussion as they are completed, regardless of order. Following publication and discussion of the final installment, the committee will review and combine the groups for consideration as an ACI standard.

SUGGESTED DESIGN OF JOINTS AND CONNECTIONS IN PRECAST STRUCTURAL CONCRETE 61-51

ACI-ASCE Committee 512—Aug. 1964, pp. 921-938

This report presents methods by which joints for use in precast concrete construction may be designed. The recommendations are intended to help provide that all joints and connections perform their function at all stages of loading without overstress and with proper safety factors against failure due to overload. The joints and connections discussed are those between precast members, between precast members and cast-in-place concrete members, and between precast members and structural steel members.

SHEAR BOND STRENGTH BETWEEN COARSE AGGREGATE AND CEMENT PASTE OR MORTAR 61-52

Michael A. Taylor and Bengt B. Broms—Aug. 1964, pp. 939-958

Microscopic cracks which develop during settling and hardening, and during subsequent loading form either in the cement or mortar matrix, or along the aggregate-matrix interfaces. The latter cracks may be caused either by tensile or by shear stresses (tensile or shear bond cracks, respectively), or by combinations of tensile and shear stresses.

The shear bond strength at the interface, as affected by type of aggregate and composition of cement or mortar matrix (at different water-cement and cement-sand ratios), has been investigated. The shear bond strength is evaluated in terms of the friction angle ϕ and the cohesion c. The shear bond strength was found to be governed chiefly by the internal friction and ϕ which appears to be nearly independent of the composition of both aggregate and matrix.

A hypothesis for predicting location and development of shear bond cracks is presented. Its validity has been investigated by microcrack studies on longitudinal slices cut from plain concrete cylinders which have been loaded in axial compression.

FLAT PLATE STRUCTURES* 61-53

John F. Brotchie and J. J. Russell—Aug. 1964, pp. 959-996

A simplified procedure for analysis of flat plate structures is presented. The results obtained from this analysis are utilized to control behavior in the structure virtually throughout the loading range. The end result is a simple method for directly designing flat plate structures both of reinforced concrete and prestressed concrete, allowing optimum behavior and maximum material economy to be directly obtained.

FLEXURAL CRACKING IN TWO-WAY CONCRETE SLABS REINFORCED WITH HIGH STRENGTH WELDED WIRE FABRIC . . . 61-54

Edward G. Nawy—Aug. 1964, pp. 997-1008

A detailed investigation is reported on the flexural cracking behavior of two-way concrete slabs reinforced with cold-drawn plain high strength welded wire fabric: Large scale square slab panels were used. They were simply supported or clamped and were centrally loaded.

Crack width propagation was observed with illuminated microscopes at close space intervals on the major cracks. Strain in the wire reinforcement was electronically recorded in the locations where the crack widths were observed. Compressive strain in the concrete and deflection at critical locations were also measured. The size and spacing of the wire were varied in the different specimens to observe their effect on the cracking behavior.

CONTINUITY OF PRISMATIC NORTHLIGHT SHEDS THROUGH THEIR WINDOW PLANES 61-55

Amin Ghali—Aug. 1964, pp. 1009-1020

Paper deals with sheds in the form of cylindrical shells or folded plates usually built spanning in the east-west direction with the windows facing north. The stresses in the direction of the span can be calculated by the Lundgran beam method. Consecutive shed units are normally connected by posts between the windows. In this paper the sheds are assumed to be of one span, and consecutive shed units are connected, apart from the window posts, by a solid wall for a short distance in the window plane near the two supports. This creates a special type of continuity which is shown to have a considerable effect on the stresses in the direction of the span. A method of calculation is presented in which the effect of this continuity is taken into consideration. A numerical example is given of a shed of the shell type

RESPONSE OF SINGLY REINFORCED BEAMS TO CYCLIC LOADING 61-56

B. P. Sinha, Kurt H. Gerstle and Leonard D. Tulin—Aug. 1964, pp. 1021-1038

Reports on an investigation of the response of simply supported beams to arbitrary cyclic load histories. A bending theory of reinforced beams is developed and compared with test results. Comparison indicates that the theory may give a rough indication of the behavior of reinforced concrete beams under cyclic loading.

PROPOSED REVISION OF RECOMMENDED PRACTICE FOR EVALUATION OF COMPRESSION TEST RESULTS OF FIELD CONCRETE (ACI 214-57) 61-57

ACI Committee 214—Sept. 1964, pp. 1057-1072

Statistical methods provide valuable tools for assessing results of strength tests, and such information is also of value in refining design criteria and specifications. The report discusses briefly the numerous variations that occur in the strength of concrete and presents statistical methods which are useful in interpreting these variations. Criteria are offered that can be used to establish specifications and maintain required uniformity. An appendix presents a simplified version of statistical quality control procedures.

PROPOSED REVISION TO ACI STANDARD—MANUAL OF STANDARD PRACTICE FOR DETAILING REINFORCED CONCRETE STRUCTURES (ACI 315-57) 61-58

ACI Committee 315—Sept. 1964, pp. 1073-1090

This manual presents recommended methods and standards for preparing drawings for the fabrication and placing of reinforcing steel in reinforced concrete structures.

The manual is up-dated to conform to design concepts of the new ACI Building Code (ACI 318-63) including torsion reinforcing, staggered column splices, simplified column tie layouts, all lap splices, closer tolerances in placing reinforcement, and simplified hook splices. New developments in materials and methods of construction recognized include electronic computer detailing, prestressed concrete, precast concrete, special large reinforcing bars, high yield point reinforcement, deformed welded wire fabric, and welded or mechanical butt splices.

CONCRETE SHELL STRUCTURES—PRACTICE AND COMMENTARY 61-59

ACI Committee 334—Sept. 1964, pp. 1091-1108

A report on the practical aspects of shell design including recommendations and a commentary for designers of thin concrete shells. General guidance based on current practice is given on analysis, proportioning, reinforcing and construction. A selected bibliography on analytical methods featuring design tables and aids is included to assist the engineer.

CARBONATION AND SHRINKAGE STUDIES OF NONPLASTIC, EXPANDED SLAG CONCRETE CONTAINING FLY ASH* 61-60

George W. Washa and Richard L. Fedell—Sept. 1964, pp. 1109-1124

This paper presents the results of carbonation and shrinkage studies of nonplastic, expanded slag concrete made with and without fly ash. Test specimens were subjected to moist, low pressure steam and high pressure steam curing conditions. Five different storage conditions including normal air drying, oven drying, and carbonation treatments at various ages and concentrations were used. All specimens were subjected to a final carbonation and two wet-dry cycles at the end of the storage period. Test results show that some carbonation treatments are effective in reducing later shrinkage.

DAMPING CHARACTERISTICS OF PRESTRESSED CONCRETE 61-61

Joseph Penzien—Sept. 1964, pp. 1125-1148

Reports on an investigation to determine the basic damping characteristics of prestressed concrete beams under dynamic loading. The basic structural parameters varied in the experiment were: type of prestress, intensity of prestress, and ultimate strength of concrete. The dynamic conditions imposed on each specimen were steady state forced vibration and free vibration about the static unloaded equilibrium position. Internal damping was observed to depend a great deal on loading history and on amplitude of displacement. It was also observed that cracking of concrete is an important parameter. Therefore, magnitude and type of prestress have an indirect influence on damping since they control cracking to a considerable extent. Most of the equivalent viscous damping factors measured ranged from 0.5 to 7.0 percent of critical values depending on the degree of cracking permitted in each test.

ENGINEERING FEATURES OF FREE-FORM CONCRETE THIN SHELL FOR EASTMAN KODAK PAVILION 61-62

Lev Zetlin—Oct. 1964, pp. 1249-1260

The roof of the main building of the Eastman Kodak Pavilion at the 1964-1965 New York World's Fair consists of a free-form shell covering a 60,000 sq ft area. The shell has undulating surfaces, not definable geometrically, and is penetrated by a number of large openings.

Construction of the shell and testing and control procedures of lightweight concrete are discussed. Brief mention is made of those design features which affected the construction of the shell.

STUDY OF THE MECHANISM THROUGH WHICH CALCIUM CHLORIDE ACCELERATES THE SET OF PORTLAND CEMENT . . . 61-63

Arnold M. Rosenberg—Oct. 1964, pp. 1261-1270

A kinetic study of the reaction between calcium chloride and portland cement was made. It was found that: (1) Although calcium chloride reacts with C_3A, the reaction rate, particularly in the presence of gypsum, is too slow to account for the set acceleration; (2) $CaCl_2$ definitely accelerates strength development in hydrating C_3S but does not react chemically with the C_3S; (3) Electron micrographic evidence suggests that $CaCl_2$ alters the shape of the hydration products formed when cement sets.

BEHAVIOR OF MORTAR FILLED STEEL TUBES IN COMPRESSION 61-64

Harold J. Salani and James R. Sims—Oct. 1964, pp. 1271-1284

Elastic and inelastic behavior of mortar filled tubes in compression was investigated. The work was restricted to seamless steel tubes ranging from 1 to 3 in. in diameter. Experimental values of the ultimate axial load capacities are compared to the theoretical values obtained from the tangent modulus formula.

PRISMATIC FOLDED PLATES—A SIMPLIFIED PROCEDURE OF ANALYSIS 61-65

Eliahu Traum—Oct. 1964, pp. 1285-1304

A simplified, yet exact procedure for the analysis of prismatic folded plates is presented. The ridges are first considered as unyielding supports for the calculation of all transverse moments in the slab. Then they are subjected to unknown loads which constitute the true slab reactions, taking into account the settlement of the ridges. One single moment distribution is sufficient to express the relationship between those reactions. A set of linear simultaneous equations yields their exact values. The method is illustrated by a numerical example.

BEHAVIOR OF REINFORCED CONCRETE FRAMES SUBJECTED TO REPEATED REVERSIBLE LOADS 61-66

Vitelmo V. Bertero and George McClure—Oct. 1964, pp. 1305-1330

Five model frames were tested with the primary objective of determining if it would be possible to disregard the problem of alternating plasticity for the case of reinforced concrete frames.

Two of the model frames were tested under proportional loading to apparent collapse to determine the instantaneous collapse load. Each of the other three frames were subjected to a large number of cycles of ultra severe alternating overloads, and then loaded to apparent collapse.

The test conducted under repeated alternating overloadings indicated that the bond strength around the critical sections, and the stiffness of the frames, were greatly reduced by repetition of the alternating overload cycles. However, the frames were not damaged so far as their ultimate strengths were concerned.

INSPECTION AND MAINTENANCE OF CONCRETE IN SERVICE 61-67

I. D. MacKenzie—Nov. 1964, pp. 1345-1358

A continuing inspection by nonoperating personnel was organized some 20 years ago to assess the condition of structures making up a large hydro-electric power system. The purpose of this program is to insure that all structures are maintained in such condition that they can safely perform all functions for which they were designed. A secondary result of the inspection is the virtual elimination of major unforeseen maintenance expenditures.

As a part of this service, the cause of deterioration of structural materials is determined, if possible, before recommendations for repair complete with cost estimates are submitted to the owner. The program has been developed to such a stage that major items of concrete maintenance can be scheduled 5 years in advance, with a tentative schedule drawn up for the following 5 years.

This paper is limited to methods of concrete inspection and maintenance. Methods of concrete repair found to be suitable in the area, which extends to the southerly limit of the boreal or northern climatic region, are described briefly.

DYNAMIC PROPERTIES OF REINFORCED AND PRESTRESSED CONCRETE STRUCTURAL COMPONENTS 61-68

M. L. James, G. M. Smith and L. D. Lutes—Nov. 1964, pp. 1359-1382

Sixteen concrete beams were subjected to sinusoidal exciting forces of varying magnitudes for the purpose of evaluating the flexural rigidity and internal damping properties. Experimental data were obtained for both reinforced and prestressed beams fabricated with Haydite aggregate and a siliceous aggregate. The percent of reinforcement was varied for the reinforced concrete beams.

The studies indicated that: (a) Modulus of elasticity of the prestressed concrete made with siliceous aggregate was 20 to 30 percent higher than that of companion reinforced concrete beams. (b) Damping in reinforced and prestressed concrete beams was not viscous for small amplitudes of vibration. (c) Prestressed beams, with siliceous aggregate, showed much greater resistance to cracking than regular reinforced beams. (d) The effect of uniaxial prestress on a concrete plate indicates that the modulus of elasticity in the direction of prestress in the plate was raised approximately 26 percent.

HORIZONTAL SHEAR CONNECTIONS BETWEEN PRECAST BEAMS AND CAST-IN-PLACE SLABS 61-69

J. C. Saemann and George W. Washa—Nov. 1964, pp. 1383-1410

This project has been concerned with the strength of the joint between precast concrete beams and cast-in-place concrete slabs. In the experimental program 42 beams and necessary control cylinders were tested in an attempt to provide information on the following variables: degree of roughness of contact surface, length of shear span, percentage of steel across the joint, effect of shear keys, position of the joint with respect to the neutral axis, and concrete compressive strength. Results obtained indicate complex relations between roughness of surface joint, percent steel across joint, and shear span.

TESTS OF STRUCTURAL BOND OF MASONRY MORTARS TO CONCRETE BLOCK . . . 61-70

R. E. Copeland and Edwin L. Saxer—Nov. 1964, pp. 1411-1452

Reports the effects of various factors on tensile and shear bond of masonry mortars with a view to establishing a basis for recommendations for obtaining strong joints. Tests were conducted to determine the effect of mortar materials, specimen storage, mortar mixes, variations in block composition, differences in block curing, and type of masonry assemblage. Also in one test series the tensile bond of epoxy adhesives used in place of mortar was investigated.

ULTIMATE STRENGTH IN COMBINED BENDING AND TORSION OF CONCRETE BEAMS CONTAINING ONLY LONGITUDINAL REINFORCEMENT 61-71

Hans Gesund and Lawrence A. Boston—Nov. 1964, pp. 1453-1472

Rectangular concrete beams were tested to destruction under combined bending and torsional loads. The beams contained only longitudinal reinforcement, and concrete strength, amount of reinforcement, and moment torque ratios were varied. A theoretical model was developed from the observed failure mechanisms, and was used to check the test results.

Yoshiji Matsumoto—Dec. 1964, pp. 1489-1508

As a result of a study, a multispan rigid frame was selected as the standard type for elevated bridges on the new 320-mile railroad connecting Tokyo and Osaka. This paper describes the preliminary design to select a standard frame, and the design and construction techniques used for the nearly 70 miles of bridges which incorporate the selected standard. Details are presented on torsional moments in double-tee beams; design of beams; problems concerning the slabs and columns; lateral stiffness and earthquake resistance; footings; and foundation settlement.

Hans Gesund, Frederick J. Schuette, George R. Buchanan, and George A. Gray—Dec. 1964, pp. 1509-1522

Rectangular concrete beams were tested to destruction under combined bending and torsional loads. The beams contained both longitudinal and transverse reinforcement, and concrete strength, amount and spacing of reinforcement, and moment-torque ratios were varied. A theoretical model was developed from the observed failure mechanisms and was used to check the results of these tests and also the results of other tests reported in the literature.

J. Dundurs and O. C. Zienkiewicz—Dec. 1964, pp. 1523-1534

A solution of an elastic, conducting circular inclusion in an elastic medium subject to a uniform temperature gradient is presented. The problem has several practical applications, but interest on it was focused by the increasing use of reinforced concrete in situations of high temperature gradients, such as nuclear reactor shields. The magnitude and distribution of stresses around a steel reinforcing bar in concrete is studied in some detail.

Bengt B. Broms—Dec. 1964, pp. 1535-1558

The flexural cracks which form in reinforced concrete beams cause a stress redistribution which results in secondary shear and normal stresses. It is possible to predict this stress redistribution by a simple method based on equilibrium requirements. High secondary shear stresses, which probably contribute to the development of diagonal tension cracks, were calculated to act close to the neutral axis. Also, secondary transverse tensile stresses were calculated within the compression zone and at the level of the reinforcement. It is hypothesized that the horizontal cracks which result from these lateral tensile stresses affect the failure mechanisms of these members.

V.62 SYNOPSES

Institute papers and reports of Proceedings V. 62 (January-December 1965 ACI JOURNAL)

Subcommittee 2, ACI Committee 211—Jan. 1965, pp. 1-22

This proposed standard is intended as a supplement to ACI Standard "Recommended Practice for Selecting Proportions for Concrete (ACI 613-54)." The standard describes a procedure for proportioning concretes having slumps in the range of zero to 1 in. and consistencies below this range, for aggregates up to 1-1/2 in. maximum size. Suitable equipment for measuring such consistencies is described. Tables similar to those in ACI 613-54 are provided which, along with laboratory tests on physical properties of fine and coarse aggregate, yield information for obtaining concrete proportions for a trial mixture. Examples of the use of these tables, in conjunction with tables in ACI 613-54, are given.

German Gurfinkel—Jan. 1965, pp. 23-34

The analysis, design, and construction of the precast frames of the Residence Halls for the University of Havana are discussed with particular attention being given to the erection procedure. Considerations are also made of the savings in cost and time obtained by erecting complete structural frames in one operation.

Bengt B. Broms—Jan. 1965, pp. 35-44

A method is described by which the internal crack pattern, crack width, and crack spacing in reinforced members can be investigated.

The method consists of injecting a resin into loaded tension or flexural reinforced concrete members. The applied load is maintained for 6 to 8 hr while the resin is allowed to set. The members are then cut open by a diamond saw and the internal cracks (maintained in their original positions) are studied with a microscope.

Phillip L. Gould—Jan. 1965, pp. 45-70

The problem of shear wall-frame interaction is investigated by a method which emphasizes the physical interrelationships between the components and minimizes the mathematical complexity. The problem is reduced to that of a cantilever beam supported by concentrated elastic reactions. Expressions are derived to set up a simultaneous equation solution for deflections at each story. The simplifications and assumptions in the analysis are discussed and procedures for extending the scope of the solution to more complex problems are given. Several examples are considered and compared to solutions by other methods.

Phil M. Ferguson and J. Neils Thompson—Jan. 1965, pp. 71-94

Supplementing an earlier report on # 3, # 7, and a few # 11 bar beams, this investigation reports on 33 # 11 bar beams and seven # 18S bar beams, all of ASTM A431 steel having f_y above the 75 kips per sq in. minimum. Bar cover, beam width, stirrup ratio, development length, and depth of concrete cast below the bar were the primary variables.

Diagonal tension limitations, at much lower stresses than expected, complicated these tests and possibly lowered the recorded bond values. The previously reported decrease in bond resistance with increasing development length showed to be less significant for lengths greater than 50 in. and possibly the resistance even levels off.

Crack width at service load seemed significant for these large high strength bars when development lengths were above 40 in., but crack width seemed little worse for a 101-in. length with a # 18S bar than for a 50-in. length with a # 11 bar.

Extra cover over the bar increased bond resistance but was not helpful in reducing surface crack width. Ordinary stirrups offset the reduction of bond strength brought about by placing two bars in a beam (equivalent to a narrower beam per bar) but otherwise generally added little to bond strength or crack width control.

Frederick O. Ruud—Jan. 1965, pp. 95-104

Development of criteria for the prediction of thermal stresses in concrete dam construction block during cooling operations prior to grouting is outlined. A new concept is presented concerning the tensile stress within a block which includes the ratio of the height of the temperature transition zone to the base length of the block being cooled.

It is shown that high temperature gradients in a concrete block will lead to excessive tensile stresses resulting in cracking of the block. Control of the maximum stress may be achieved through cooling operations leading to acceptable temperature gradients. Several curves are given for prediction of maximum tensile stress as a function of base length, height of temperature transition zone, temperature change, and properties of the concrete.

Gene Alan Metz—Jan. 1965, pp. 105-116

Results are presented from tests on 16 small reinforced concrete slabs. Fifteen of the slabs were loaded with a uniform load, approximated by a large number of point loads;

the other slab was loaded with a concentrated load. Test results are compared with the ultimate failure loads and failure crack patterns as predicted by theory.

FIFTEEN YEARS OF SLIP-FORM PAVING 62-8

Gordon K. Ray and Harold J. Halm—Feb. 1965, pp. 145-160

Traces the development of slip-form concrete paving in the United States. Covers the period since the first half-mile project was built in Iowa in 1949 through the 1963 construction season when several hundred miles of paving were built with slip-form pavers. The early developmental machines are described and the newer improved and electronically controlled slip-form pavers which are now being used to build high-speed turnpikes, expressways, and interstate highways as well as light traffic secondary roads are also discussed.

The principles of slip-form paving are described, the requirements for adequate subbase preparation are discussed and some of the important considerations for proper mix proportioning are outlined. Illustrations of slip-form pavers for a wide variety of projects, which demonstrate the versatility of this equipment, are presented. Offers some of the data to date which prove the excellent riding qualities which can be obtained through the use of slip-form construction.

ULTIMATE STRENGTH DESIGN FOR BENDING BY ITERATION 62-9

Alfred Zweig—Feb. 1965, pp. 161-168

A design procedure is presented which makes it possible to find the required reinforcing steel for bending with the ultimate strength method by means of a direct and iterative approach without the use of nomographs. The first approximation is as easily obtained as when using the working stress method and in all practical cases only one corrective iteration is necessary.

FATIGUE BEHAVIOR OF BUTT-WELDED REINFORCING BARS IN REINFORCED CONCRETE BEAMS 62-10

J. C. Walls, W. W. Sanders, Jr., and W. H. Munse—Feb. 1965, pp. 169-192

Fatigue tests were conducted on 23 reinforced concrete beams which contained single-V-butt-welded reinforcement. Most of the beams were reinforced with one #7 intermediate grade billet-steel reinforcing bar. Four beams, however, were reinforced with additional reinforcement to obtain an indication of the effect of variation in percentage of reinforcement and total bar perimeter. The majority of the tests were conducted with the load varying from zero to maximum, however, some of the tests of beams with one #7 reinforcing bar were conducted at a load range of one-half maximum to maximum.

S-N diagrams for the beams were obtained and the results are compared with the results of tests on 60 deg single-V-butt-welded bars tested axially. From a study of these results, methods for estimating the fatigue life of reinforced concrete beams with butt-welded reinforcement have been obtained.

INFLUENCE OF AGGREGATE AND VOIDS ON MODULUS OF ELASTICITY OF CONCRETE, CEMENT MORTAR, AND CEMENT PASTE 62-11

Torben C. Hansen—Feb. 1965, pp. 193-216

On the basis of general theories for two-phase materials, formulas have been derived from which the modulus of elasticity can be calculated for concrete, cement mortar, and cement paste, when the modulus is known for the component materials. Experimental verification is offered and a numerical example is worked out which illustrates practical application of the formulas.

COLUMN DETAILS UNDER THE 1963 ACI BUILDING CODE 62-12

Donald E. Anderson and Edward S. Hoffman—Feb. 1965, pp. 217-230

The 1963 ACI Code criteria for columns are compared with the 1956 Code. Comparative costs are presented for columns showing the effect of four basic variables: the type of column, concrete strength, reinforcing steel strength, and percentage of steel. Lapped column splices and four types of butt splices are discussed. A sample column schedule for columns with butt splices is presented showing the intended bar and tie arrangement, splice locations, and dowel patterns. The ultimate strength design and working stress design methods for columns are compared under the 1956 and 1963 Code. The procedure for constructing a working stress design interaction diagram is demonstrated. The 1963 Code criteria for length of columns and capacity of long columns are discussed and compared with the 1956 Code.

SPACING OF LATERAL SUPPORTS FOR MASONRY WALLS* 62-13

Robert H. Krone and Richard N. Pollitz—Feb. 1965, pp. 231-238

The interpretation of some building codes regarding the spacing of lateral supports or the limiting of the stresses in masonry walls for stability against wind pressures seem to vary among engineers. To emphasize the need for a clarification of the codes in this matter, the results of an analytical study of hollow block masonry walls is presented. From this study graphs have been prepared for ease of evaluating the stability of a masonry wall based on its combined strength in the vertical and horizontal directions.

STRENGTH OF CONCRETE UNDER BIAXIAL COMPRESSION 62-14

K. T. Sundara Raja Iyengar, K. Chandrashekhara, and K. T. Krishnaswamy—Feb. 1965, pp. 239-250

A criterion for failure of concrete under combined stresses has been studied by testing concrete cubes to failure under biaxial compression. From the results of these tests, correlations between the octahedral normal and shear stresses and the principal stresses in dimensionless form were obtained. It was found that a criterion of failure based on the principal stresses is more useful for practical purposes. Similar results were obtained for cement mortar. The failure criterion for concrete under tensile and compressive stresses is also discussed.

BOND STRENGTH OF REINFORCEMENT AFFECTED BY CONCRETE SEDIMENTATION 62-15

Geoffrey B. Welch and Bruce J. F. Patten—Feb. 1965, pp. 251-264

Experimental investigations to examine the effect of concrete sedimentation characteristics on pull-out bond strengths are reported. Concretes of the same compressive strength but varying settlement and bleeding were used with plain round, square, twisted, and deformed bars. The general trend of the results indicated that increased concrete settlement in all cases led to reduced bond of rigidly positioned, horizontal bars, even with small depths of plastic concrete beneath the bars.

RECOMMENDED PRACTICE FOR EVALUATION OF COMPRESSION TEST RESULTS OF FIELD CONCRETE (ACI 214-65) 62-16

Announcement of ACI standard

Separate copies of the standard available

ACI 214-65 supersedes ACI 214-57 and Title No. 61-57

ACI Committee 214—Mar. 1965, p. 273

Statistical methods provide valuable tools for assessing results of strength tests, and such information is also of value in refining design criteria and specifications. The report discusses briefly the numerous variations that occur in the strength of concrete and presents statistical methods which are useful in interpreting these variations. Criteria are offered that can be used to establish specifications and maintain required uniformity. An appendix presents a simplified version of statistical quality control procedures.

MANUAL OF STANDARD PRACTICE FOR DETAILING REINFORCED CONCRETE STRUCTURES (ACI 315-65) 62-17

Announcement of ACI standard

Separate copies of the standard available

ACI 315-65 supersedes ACI 315-57 and Title No. 61-58

ACI Committee 315—Mar. 1965, p. 274

This manual presents recommended methods and standards for preparing drawings for the fabrication and placing of reinforcing steel in reinforced concrete structures.

The manual is up-dated to conform to design concepts of the new ACI Building Code (ACI 318-63) including torsion reinforcement, staggered column splices, simplified column tie layouts, all lap splices, closer tolerances in placing reinforcement, and simplified hooks. New developments in material and methods of construction recognized include electronic computer detailing, prestressed concrete, precast concrete, special large reinforcing bars, high yield point reinforcement, deformed welded wire fabric, and welded or mechanical butt splices.

GLOSSARY OF TERMS ON CEMENT AND CONCRETE TECHNOLOGY—INCREMENTS NO. 7, 8, AND 10 62-18

ACI Committee 116—Mar. 1965, pp. 275-292

As part of its mission, ACI Committee 116, Nomenclature, presents the fifth published installment of a glossary of terms on cement and concrete technology. The glossary has been divided into 13 increments which are being presented to elicit discussion as they are completed, regardless of order. Following publication and discussion of the final installment, the committee will review and combine the groups for consideration as an ACI standard.

SMALL PRECAST CONCRETE PIECES MAKE UP A MEDIUM SPAN PRESTRESSED BRIDGE 62-19

E. R. Cancio and A. Munoz F.—Mar. 1965, pp. 293-306

Discusses the design and construction of a prestressed concrete bridge built in Mexico using unusual techniques.

The 130 ft central span was made with small precast pieces. The bridge was designed in such a way that the erection could be performed without the use of falsework or cranes.

Some considerations for using the same design technique for larger spans and wider decks are presented. Total and unit costs for the project are presented.

SIMPLIFIED ULTIMATE STRENGTH DESIGN FOR FLEXURE 62-20

Prabhakar Parikh—Mar. 1965, pp. 307-314

A table is presented which simplifies ultimate strength design for flexure according to the ACI Building Code (ACI 318-63). Examples are given which illustrate the use of the table.

STRENGTH CONTRIBUTION OF A POZZOLAN TO CONCRETES 62-21

Alvaro Lopez Ruiz—Mar. 1965, pp. 315-326

The strength contribution of a pozzolan of volcanic origin in pozzolan-cement concretes with 15 to 35 percent replacements, as a function of the replacement of portland cement by pozzolan, with cements of different qualities was studied. The term "strength contribution" of a pozzolan, in pozzolan-cement concretes is defined.

DESIGN OF COLUMNS SUBJECTED TO BIAXIAL BENDING 62-22

John F. Fleming and Stuart D. Werner—Mar. 1965, pp. 327-342

A simplified ultimate strength method of design for columns subjected to bending about both principal axes is presented. A set of nondimensional design curves for one particular section geometry is given for commonly encountered values of steel percentage, concrete strength, and steel yield stress. The use of these curves is demonstrated by several design examples.

INFLUENCE OF TRANSVERSE REINFORCEMENT ON SHEAR AND BOND STRENGTH 62-23

J. R. Robinson—Mar. 1965, pp. 343-362

Reports recent work of the subcommittee on shear of the European Concrete Committee. The functions of stirrup reinforcement, bent-up bars, transverse ties, and some new types of transverse reinforcement are examined. Design methods for transverse reinforcement provided to prevent splitting are suggested. A broad program of future tests is suggested, aimed toward improved concepts and methods of design for shear and bond, with particular reference to members with high strength longitudinal reinforcement.

DESIGN AIDS FOR SQUARE FOOTINGS 62-24

Richard W. Furlong—Mar. 1965, pp. 363-372

To select footing depths which comply with the ACI Building Code, several trials usually have to be made. This paper presents some design aids which eliminate the trial and error steps and facilitate the selection of reinforcement. Some examples illustrate the use of the charts.

SUSPENDED CATENARY CABLE ROOF OF OKLAHOMA STATE FAIR ARENA 62-25

Jack L. Scott, Kenneth K. O'Malley, and Harvey G. Gulley—Apr. 1965, pp. 385-402

Describes the design and construction of the suspended catenary roof and supporting structure. The roof system is suspended on a 10-ft grid from an elliptical compression ring 68 ft above the arena floor.

THEORY FOR THE COMBINED ACTION OF BENDING MOMENT AND SHEAR IN REINFORCED AND PRESTRESSED CONCRETE BEAMS 62-26

Mogens Lorentsen—Apr. 1965, pp. 403-420

The influence of bond on the strength of reinforced and prestressed concrete beams is described. Test results described in the paper show that the presence of bond may induce shear failure.

On the basis of this observation a theory for predicting the shear strength of concrete beams, is introduced. According to the theory the shear is carried partly by beam action, partly by arch action. It is shown, that the shear strength of beams without web reinforcement may be expressed as a function of the strength of the crack lamellas, the shear span, and the flexural cracking moment.

AN UNUSUAL CASE OF SURFACE DETERIORATION ON A CONCRETE BRIDGE DECK 62-27

John Ryell—Apr. 1965, pp. 421-442

Set retarded concrete placed in a bridge deck and finished with conventional equipment exhibited a severe surface deterioration in the form of flaking several days after paving.

Similar concrete placed in the approach slab on a granular subgrade did not flake.

Laboratory and field investigations showed that the flaking was due to the formation of a weak plane immediately below the surface of the concrete and was closely connected with the bleeding characteristics of the mix.

The solution was found in reducing the bleeding rate of the concrete by a change in the type of set retarding admixture.

A SERIES OF TESTS ON SIMPLY SUPPORTED COMPOSITE BEAMS* 62-28

Peter R. Barnard—Apr. 1965, pp. 443-456

Describes a series of six tests to collapse on simply supported composite beams made up of a concrete slab and an unencased steel beam. The results show that a computer calculation making use of the actual steel and concrete stress-strain curves provided a good approximation of the experimental moment-curvature relationships and an excellent prediction of the conditions present in the beams at ultimate moment. Even when the steel beam was not fully plastic at ultimate, the ultimate strength provisions of the ACI Building Code gave an accurate prediction of the maximum load.

USE OF HIGH STRENGTH REINFORCING STEEL IN BRIDGES 62-29

E. L. Hardeman—Apr. 1965, pp. 457-466

Describes the experimental continuous concrete girder bridge built in Hill County, Tex., in which high strength reinforcing steel was used. A brief description of the installation of electric strain gages, instrumentation, and test procedures is presented. Features of the structural analysis and a comparison of the ultimate strength design with the elastic design are given. Deflections and crack formations are discussed.

EVALUATION OF CONCRETE COMPRESSION TEST RESULTS 62-30

L. R. Lauer—Apr. 1965, pp. 467-478

A graphical method is applied to the evaluation of actual compression cylinder test results of concrete from a large ready mixed concrete firm for its previous year of operation. These results are then utilized as a basis of design for succeeding jobs supplied by the firm. A graphical representation of data to obtain standard deviation, mean strength, and the coefficient of variation is shown and the results compared with the usual root mean square method of obtaining these values. The graphical method not only allows processing of data within a short time, but it also allows visual detection of deviate results.

ELASTIC TORSIONAL STIFFNESS OF PRESTRESSED CONCRETE AASHO GIRDERS* 62-31

K. G. Tamberg—Apr. 1965, pp. 479-492

Torsional stiffness values relating to four prestressed concrete AASHO girders have been calculated by the use of finite differences.

Torsional stiffness values have been calculated for the girders themselves and for the girders plus 7 in. concrete slabs, both interconnected and acting separately but with the girders and slabs rotating through the same angle.

The various widths of the 7-in. slabs considered fall into two major categories: (a) modulus of elasticity of the slab, E_S, equal to modulus of elasticity of the girder, E_G; (b) modulus of elasticity of the slab equal to 0.77 times the modulus of the girder.

Graphs relating the torsional stiffness values, K, to various slab widths for the four AASHO girders have been produced. The stiffness values read off the graphs may be used directly in the design of bridge decks when, for example, the Guyon-Massonnet or Hendry and Jaeger load distribution theories are used.

Newton's interpolation function has been used to calculate torsional shear stresses.

CONCRETE FROM A TO Z 62-32

Bryant Mather—May 1965, pp. 513-520

In this President's Address, the author reflects on the breadth, the inclusiveness, and the diversity of ACI activities.

GAP-GRADED MIXES FOR CAST-IN-PLACE EXPOSED AGGREGATE CONCRETE 62-33

Albert Litvin and Donald W. Pfeifer—May 1965, pp. 521-538

Attractive uniform exposed aggregate surfaces of cast-in-place concrete may be achieved by the use of low-slump, gap-graded aggregate mixes. These mixes required a high percentage of coarse aggregate and low water-cement ratio, resulting in excellent strength and elastic properties with low creep and drying shrinkage.

Laboratory tests and field experience indicate that concretes with matrix volumes (air, water, cement, and sand) of 45 to 50 percent can be satisfactorily consolidated and will possess excellent architectural characteristics. The importance of special care in such matters as taping of form joints, proper treatment of form ties, adequate vibration, etc., is stressed. Three typical structures are cited in which cast-in-place, gap-graded concrete was used to obtain excellent exposed aggregate surfaces.

BEHAVIOR OF ONE-WAY CONCRETE FLOOR SLABS REINFORCED WITH WELDED WIRE FABRIC 62-34

Amos Atlas, Chester P. Siess, and Clyde E. Kesler—May 1965, pp. 539-558

Studies were made of the behavior and strength of one-way concrete slabs reinforced with welded wire fabric with particular emphasis on effects of the specific properties of the fabric. Factors considered were strength and ductility of the wires coupled with an absence of a definite yield point, bond and anchorage properties that depend on both the longitudinal and the transversely welded wires, a limit of 1/2 in. on the diameter of the wires, and also the fact that slabs normally have a low percentage of reinforcement.

An expression was obtained for the average crack spacing in slabs reinforced with welded fabric. The maximum and average crack widths on the tensile face of the slab and at the level of the reinforcement were estimated.

Problems of shear strength and of anchorage in slabs were studied.

The stresses and strains at flexural failure were studied, and an expression obtained for the ultimate strength of the slabs.

Values of allowable stresses in the reinforcement to be used with the working stress method were obtained.

The behavior of slabs reinforced with draped reinforcement and of some current anchorage and splicing details were also studied.

ETTRINGITE FORMATION IN DAM GALLERY 62-35

R. A. Kennerley—May 1965, pp. 559-576

The formation of a deposit of ettringite in a submerged dam gallery is described. It occurred in an area where a fly ash-cement mixture had been used for the placement of prepacked concrete. Where fly ash was used to replace a portion of the cement in conventionally placed concrete nearby, no such deposit was observed. No evidence of deterioration of the concrete could be found.

The deposit was found adjacent to a 'stop-work' plane in the grouting of the aggregates, and it is thought that the concrete at this point could have become enriched in lighter hydration products (e.g., calcium sulfoaluminate, calcium hydroxide) and grout admixtures. The formation of ettringite as a stable product of cement hydration would have been assisted by additional sulfate derived from the fly ash.

It is believed that water seeping along permeable planes in the concrete dissolved some of the sulfate and alumina-containing phases formed during cement hydration and, on reaching the gallery, ettringite was precipitated from solution.

INFLUENCE OF NORMAL PRESSURE ON BOND STRENGTH 62-36

Raymond E. Untrauer and Robert L. Henry—May 1965, pp. 577-586

Tests were made on 37 pullout specimens with # 6 and # 9 deformed reinforcing bars having a yield strength of approximately 92,000 psi. All specimens had an embedment length of 6 in. The normal pressure applied to the pullout specimens varied from zero to 2370 psi.

Bond strength was found to increase with normal pressure in proportion to the square root of the normal pressure when other factors are constant and with the square root of the concrete strength. At ultimate, the bar size had little effect on the ultimate bond strength; however, at loaded-end slips of 0.005 and 0.01 in., the bond strength was greater for the # 9 bar than for the # 6 bar. For both bar sizes, normal pressure increased the bond strength more at ultimate than at lower slips.

REINFORCEMENT OF FOLDED PLATES 62-37

Sidney A. Guralnick and Stuart Swartz—May 1965, pp. 587-604

Starting from the point at which the longitudinal normal stresses in a folded plate structure have been determined, a procedure is developed for computing shear stresses and transverse normal stresses at any point in the structure. A method for designing the steel reinforcement is suggested and illustrated by a numerical example.

CONCRETE CORE BLOCK FOR OROVILLE DAM 62-38

Paul R. Stodola, John E. O'Rourke, and Hamilton G. Schoon—June 1965, pp. 617-634

The Oroville Dam core block was completed during the summer of 1963. The dam is on the Feather River, near the city of Oroville, in Northern California, and is a key unit of the California Water Plan. The core block is a 293,000 cu yd mass concrete structure, which is located beneath an earth-fill embankment. This paper describes the design, proportioning, production, and placing of concrete for the core block. Testing and temperature instrumentation results are presented to demonstrate what was achieved with the lean, mass concrete placed under generally hot weather conditions.

THE MARCH 27 ALASKAN EARTHQUAKE—EFFECTS ON STRUCTURES IN ANCHORAGE 62-39

Walter E. Kunze, John A. Sbarounis, and James E. Amrhein—June 1965, pp. 635-650

The effects on structures of the March 27, 1964, earthquake observed in Anchorage, Alaska, are discussed. Investigation of the damage indicates that present-day trends in building construction are producing structures with increasingly improved antiseismic characteristics. Requirements that buildings must meet if they are to withstand catastrophic earthquakes are reviewed in the article.

MASS CONCRETING PRINCIPLES APPLIED TO MASSIVE STRUCTURAL MEMBERS 62-40

J. Neil Mustard—June 1965, pp. 651-660

The use of pozzolan, a minimum of cement, large size aggregate and low slump has long been standard practice for mass concrete. This paper deals with various techniques by which these leaner, harsher mixes can be incorporated into large structural concrete members or units. The concrete with a low cement factor is placed in areas of low stress and is bonded monolithically with the higher strength concrete. This not only results in a saving of cement, but also reduces the temperature rise of thick sections and thereby decreases the tendency for them to develop cracks on cooling.

OPTIMUM STEAM CURING PROCEDURES FOR STRUCTURAL LIGHTWEIGHT CONCRETE 62-41

J. A. Hanson—June 1965, pp. 661-672

This paper describes the effect of various steam curing procedures on the compressive strength, tensile splitting strength, and modulus of elasticity of structural lightweight concrete. Particular emphasis is given to steaming procedures compatible with the time requirements of modern prestressing plants, and the investigation was patterned after a similar investigation of normal weight concrete. In addition, a half-day curing cycle was studied. The investigation was restricted to a single lightweight aggregate without the inclusion of natural sand.

The optimum conditions for steam curing of lightweight concrete were found to be little different from those for normal weight concrete. The allowable variation in the presteaming period was somewhat less. The reduction of potential strength development by steam curing was found to be less for lightweight concrete than for the normal weight material.

SMALL SCALE MODEL ANALYSIS OF THIN SHELLS 62-42

David P. Billington and Robert Mark—June 1965, pp. 673-688

The fabrication and testing of a series of small scale elastic models are presented along with a discussion of the relative merits of the various techniques used. An acrylic plastic folded plate and a filled epoxy hyperboloid of revolution were instrumented with small strain gages while a flat plate and a cylindrical barrel shell of clear epoxy were analyzed by three dimensional photoelasticity. Using the stress freezing method, these epoxy models were sliced and the bending and in-plane stresses were directly obtained from photoelastic readings.

EXPANSIVE CEMENT CONCRETES—A REVIEW 62-43

Shu-t'ien Li—June 1965, pp. 689-706

Expansive cements and concretes, although seemingly new engineering materials, have had a long history of development. During the past 74 years, there have been recurrent efforts to develop expansive cements. However, only in the last 15 years has there been successful production and application of such cements to controlled expansive concretes.

Historical developments of expansive cements in France, the Soviet Union, and the United States are briefly reviewed; salient properties of self-stressing, and shrinkage-compensated, expansive cements and concretes are summarized; current applications of expansive concretes are examined; and their potential uses are indicated.

RECOMMENDED PRACTICE FOR SELECTING PROPORTIONS FOR NO-SLUMP CONCRETE (ACI 211-65) 62-44

Announcement of ACI standard

Separate copies of the standard available

ACI 211-65 supersedes Title No. 62-1

ACI Committee 211, Subcommittee 2—July 1965, pp. 737-738

This proposed standard is intended as a supplement to ACI Standard "Recommended Practice for Selecting Proportions for Concrete (ACI 613-54)." The standard describes a procedure for proportioning concretes having slumps in the range of zero to 1 in. and consistencies below this range, for aggregates up to 1-1/2 in. maximum size. Suitable equipment for measuring such consistencies is described. Tables similar to those in ACI 613-54 are provided which, along with laboratory tests on physical properties of fine and coarse aggregate, yield information for obtaining concrete proportions for a trial mixture. Examples of the use of these tables, in conjunction with tables in ACI 613-54, are given.

FIELD TESTING EXPERIENCE ON MILWAUKEE WATER WORKS STATION 62-45

Leonard A. Hoffman and E. Walter Ibbotson—July 1965, pp. 739-750

During construction of the North Point Pumping Station in Milwaukee, the opportunity was taken to study several factors concerning the concrete being placed and a number of means of testing. Reported are the relationships found between site temperature near the forms, and internal concrete temperature; relationship between field and laboratory test cylinders; experience with the use of the rebound hammer; and experience with the ball penetration test of concrete consistency.

DESIGN CURVES FOR LONG REINFORCED CONCRETE COLUMNS 62-46

Thomas C. Edwards and Phil M. Ferguson—July 1965, pp. 751-762

The 1963 ACI Code specifies load reduction factors for long columns that are dependent on their deflected shape and flexibility (h/r ratio) and a strength reduction factor ϕ. In design the choice of the governing Code provision is not readily apparent and, even without sidesway, two loadings must be considered.

The Code further specifies that members with small compressive load may be designed for bending alone. This clause introduces the problem of determining the point where the design for axial load and bending becomes less economical than for moment alone.

The chart developed here enables the designer to compare the several cases and to quickly determine the final design in one operation.

EFFECTIVENESS OF HELICAL BINDING IN THE COMPRESSION ZONE OF CONCRETE BEAMS 62-47

G. D. Base and J. B. Read—July 1965, pp. 763-782

Reinforced and prestressed beams were tested by mid-span loading to investigate the efficiency of helical reinforcement in the compression zone as a means of improving the moment-rotation characteristics of the plastic hinges that formed.

Helices were generally more efficient than stirrups in terms of weight of steel for a specified increase in plastic rotation. Rectangular stirrups tended to deform outwards and permit the compression zone to crush. Balanced section reinforced concrete beams and rectangular prestressed beams were given adequate plasticity by helices alone, but over-reinforced beams generally required additional shear reinforcement in the form of stirrups.

INFLUENCE OF AGGREGATE PROPERTIES ON CONCRETE SHRINKAGE 62-48

Torben C. Hansen and Knud E. C. Nielsen—July 1965, pp. 783-794

A theory of the influence of aggregate properties on concrete shrinkage is presented. An equation is derived from which the shrinkage of concrete may be computed from the fractional volume, the modulus of elasticity, and the shrinkage of cement paste and aggregate. A comparison is made between theoretical and experimental results.

SHELL ANALYSIS OF INTERMEDIATE SILO BIN 62-49

Ryszard Dabrowski—July 1965, pp. 795-804

A group of four circular silo bins enclosing one intermediate bin, the latter being acted on by the pressure of granular material, is analyzed on the basis of shell theory. The results are compared with those of a simplified analysis in which the system is considered as a plane frame.

EFFECTS OF FLEXURAL STRAIN GRADIENTS ON MICROCRACKING AND STRESS-STRAIN BEHAVIOR OF CONCRETE 62-50

Gerald M. Sturman, Surendra P. Shah, and George Winter—July 1965, pp. 805-822

To investigate the influence of flexural strain gradients on microcracking and the stress-strain behavior of plain concrete, eccentrically and concentrically loaded specimens were compared. It was found that a flexural strain gradient retards microcracking, especially mortar cracking as compared to cracking at the same strain in axial compression. The stress-strain curve for eccentric compression, which was computed by an experimental statistical approach, was found to differ materially from that for concentric compression. The peak of the flexural curve was located at a strain about 50 percent higher and at a stress about 20 percent larger than the peak of the curve for concentric compression. Structural implications of these findings are discussed briefly.

RESPONSE OF DOUBLY REINFORCED CONCRETE BEAMS TO CYCLIC LOADING* 62-51

G. L. Agrawal, Leonard G. Tulin, and Kurt H. Gerstle—July 1965, pp. 823-836

The response of doubly reinforced concrete beams to variable repeated and reversed loading is predicted on the basis of technical beam theory and stress-strain relations of steel and concrete under cyclic loading. A series of tests was performed to verify the theory. It is concluded that the response to repeated loading may be considered elastic-plastic for engineering purposes, but the behavior under alternating plasticity is highly nonlinear which can be predicted only by considering the Bauschinger effect in the steel.

GLOSSARY OF TERMS ON CEMENT AND CONCRETE TECHNOLOGY INCREMENT NO. 13 62-52

ACI Committee 116—Aug. 1965, pp. 865-868

As part of its mission, ACI Committee 116, Nomenclature, presents the sixth published installment of a glossary of terms on cement and concrete technology. The glossary has been divided into 13 increments which are being presented to elicit discussion as they are completed, regardless of order. Following publication and discussion of the final installment, the committee will review and combine the groups for consideration as an ACI standard.

HIGH PRESSURE STEAM CURING: MODERN PRACTICE, AND PROPERTIES OF AUTOCLAVED PRODUCTS 62-53

ACI Committee 516—Aug. 1965, pp. 869-908

High pressure steam curing (autoclaving) is employed in the production of concrete masonry units, sand-lime brick, asbestos-cement pipe, hydrous calcium silicate-asbestos heat insulation products, and lightweight cellular concrete. While all are covered, this report emphasizes concrete masonry units because they represent the greatest use of autoclaving in the United States and Canada, and most of the information available is in this field. The chief advantages offered by autoclaving are high early strength, reduced moisture volume change, increased chemical resistance, and reduced susceptibility to efflorescence.

Many properties of concretes are improved by autoclaving, however, some, such as permeability and brittleness are not. The report presents a summary of modern practice and makes general comparisons of physical properties of autoclaved products.

CORROSION OF REINFORCING BARS IN CONCRETE 62-54

John D. Mozer, Albert C. Bianchini, and Clyde E. Kesler—Aug. 1965, pp. 909-932

Presents information on the nature and mechanics of corrosion of reinforcing bars in concrete. Discusses the factors associated with the concrete and steel which cause corrosion and the preventative methods to inhibit corrosion. The paper has been written primarily for the engineer rather than the scientist.

Phil M. Ferguson, John E. Breen, and J. Neils Thompson—Aug. 1965, pp. 933-950

Pullout tests using unsymmetrical specimens with spirals around the bars are reported on # 14S and # 18S bars in comparison with # 7 bars, all of ASTM A431 steel.

The longer specimens developed high steel and bond stresses even though loaded end slip was large. Loaded end slip varied approximately in proportion to bar diameter but the length of embedment had little influence on the f_s developed at a loaded end slip of 0.010 in. Rather than consider crack width as twice this loaded end slip, direct observations on beams are recommended as more reliable.

Unloaded end slip was not significant except in top cast bars. These top bars slipped at the unloaded end at relatively small loads, even before splitting started in some cases.

Katharine Mather—Aug. 1965, pp. 951-962

Any sound concrete, in sections of sufficient thickness, can be used to construct a satisfactory biological shield. When space permits, conventional concrete is the most economical, satisfactory shield against radiation. However, when space is a consideration, high density concrete can be used for shielding. Most high density concrete for shielding has been made with naturally occurring iron ores, titaniferous iron ores, "hydrous iron ores," and barite. Although structural strength is an important factor in high density concrete, workability and density have been the major factors previously studied.

This investigation showed that high strength concrete can be made using materials that provide high density, and that high density concrete can be made using proportions that ensure high strength. When high strength and high density are both desired, they can be attained by a direct combination of the standard practices developed for attaining each condition separately. Concrete made as part of this study using magnetite aggregate or ilmenite aggregate having a hardened unit weight of about 230 lb per cu ft had a compressive strength of 9000 psi at 7 days and 11,000 psi at 28 days.

Noel J. Everard—Aug. 1965, pp. 963-976

The basic assumptions stated in the 1963 ACI Code are used with specific locations of the neutral axis for spirally reinforced columns and tied columns to accurately calculate the corresponding values of P_u, M_u, and the eccentricity e. The values of e/t are then used in the ACI Code equations to predict the approximate values of P_u. The exact values of P_u are compared with the values predicted by the Code equations to ascertain the error of the latter for the given conditions.

The computer solutions used by the author to prepare design charts for ACI Committee 340 are also compared to the exact solutions and it is shown that the differences are negligible. The related computer programs are therefore shown to be satisfactory for use as a means of evaluating the ACI Code equations.

This study marks the beginning of an effort to establish the limits of applicability of the Code equations, and to attempt to devise correction factors which will extend the range of usefulness of the Code equations.

William A. Cordon and J. Derle Thorpe—Aug. 1965, pp. 977-986

Rapid drying on the exposed surface of concrete may result in finishing problems such as stickiness, sponginess, and unevenness; plastic shrinkage and cracking; or a compacted surface which creates a layered structure subject to scaling. These undesirable characteristics may be corrected by control of evaporation with a monomolecular film on the surface of bleeding water. Laboratory tests and field experiences are discussed.

Vedat A. Yerlici—Aug. 1965, pp. 987-992

The strength and extension of plain concrete under short-time, repeated, and sustained axial tensile load are discussed. Formulas are given to approximate instantaneous and time dependent strain of concrete under constant or variable tensile stress.

ACI Committee 306—Sept. 1965, pp. 1009-1036

The general requirements for producing satisfactory concrete during cold weather are discussed, as are methods for achieving these requirements. It is emphasized that for many structural concretes, protection considerably in excess of that required to insure freedom from damage by early freezing is required to assure safe development of strength. Accelerators, keeping of temperature records, heating of materials, subgrade preparation, protective insulating coverings, heated enclosures, curing, and form removal are discussed. Supplementary material on the effect of curing temperatures on concrete strength is referenced in authoritative sources. A list of selected references is included.

Ulrich Finsterwalder—Sept. 1965, pp. 1037-1046

Since 1950, about 90 prestressed bridges have been built using the free cantilever system of construction. The system is described and several projects discussed.

A new concept in prestressed bridge construction, the stress ribbon bridge, is also discussed. This system uses a stress ribbon of concrete hanging in a funicular curve cantilevered from the piers at both ends. The stress ribbon concept is equivalent to the steel suspension bridge for concrete construction. While none have been built to date, several proposed bridges are described.

A. Murray Lount—Sept. 1965, pp. 1047-1062

The computer is becoming the focal point of a complete revolution in the approach to engineering problems. However, the best use of this new tool is not made under existing engineering office organization and as a mere replacement for manual labor. Proper use of computers depends on knowing what they can and cannot do.

This paper examines five areas where computers have been, or can be, used with success. The problems of analysis and design, routine operations such as detailing, research, tabular data, and optimization and probability analysis are discussed. Some examples of work where computers were used are presented. It is concluded that the use of computers may lead to a complete reassessment of many aspects of concrete design and practice and it is suggested that the time for some of this may be now.

LAPPED SPLICES FOR HIGH STRENGTH REINFORCING BARS* 62-63

Phil M. Ferguson and John E. Breen—Sept. 1965, pp. 1063-1078

Tests of 35 beams, each containing lapped splices of # 8 or # 11 bars of high strength steel in a constant moment region, are reported. Splices with # 11 bars behaved exceptionally well, developing bond stresses slightly higher than the # 8 bars and indicating that the ACI Code splice provisions for # 11 bars are a little severe. The shape of the steel stress-strain curve had little influence on splice strength. No loss in bond strength developed when steel strains as high as 0.006 to 0.009 were reached. One # 11 bar specimen at a steel strain of 0.011 developed lower bond resistance but a # 8 bar specimen at 0.012 strain showed no such effect. The few beams having stirrups over the splices gave higher strengths, but the main study was related to splices without stirrups.

A PIN-CONNECTED PRECAST STADIUM 62-64

German Gurfinkel—Sept. 1965, pp. 1079-1094

The design and erection of a prefabricated stadium are fully discussed. Special attention is given to connections between precast members and to the criteria that governed the economical prefabrication of the structure.

STRESS DISTRIBUTION IN REINFORCED CONCRETE MEMBERS WITH TENSION CRACKS* 62-65

Bengt B. Broms—Sept. 1965, pp. 1095-1108

The axial stress distribution parallel with and perpendicular to the main reinforcement was investigated for tension, compression, and flexural members with tension cracks. The measured surface strain distribution is compared with the calculated distribution assuming that concrete behaves as an ideal elastic material.

NOVEL STRUCTURAL FRAME COMBINED WITH SLIP-FORM CONSTRUCTION RESULTS IN RECORD BREAKING CONSTRUCTION TIME 62-66

Vincent J. De Simone and Joseph F. Camellerie—Oct. 1965, pp. 1225-1236

The structural frame of a 25-story condominium apartment house was constructed in 35 days as a result of combining slip-formed bearing walls with precast prestressed floor beams.

Construction details, slip-form loads, and floor inserts are described briefly. The use of a climbing crane with its loads, coupled with critical path method, show interesting results.

CRACK WIDTH AND CRACK SPACING IN REINFORCED CONCRETE MEMBERS* 62-67

Bengt B. Broms—Oct. 1965, pp. 1237-1256

A simple method is developed for calculation of crack width and crack spacing in reinforced concrete members. The crack widths determined by this method were compared with test data obtained from flexural and tensile members reinforced with one bar.

The shape of the main cracks was investigated by means of short tension members of a length equal to the spacing of the main tension cracks. The internal crack formation was determined during loading through injection of resin into a few test specimens. After the resin had hardened and the test members were cut open, the internal crack formation was studied.

ULTIMATE STRENGTH DESIGN 62-68

Malcolm S. Gregory—Oct. 1965, pp. 1257-1264

The behavior of concrete sections at failure is considered and the validity of ultimate strength design methods demonstrated. The difficulties experienced by design engineers in applying existing code formulas are summarized. An understanding of the basic principles of ultimate strength methods leads to rapid and direct design. Numerical procedures suitable for design office use are suggested and illustrated by examples. The argument is advanced that codes of practice might present the basic principles and required empirical data, and avoid difficult algebraic formulas.

SIGNIFICANCE OF DOWEL FORCES ON THE SHEAR FAILURE OF RECTANGULAR REINFORCED CONCRETE BEAMS WITHOUT WEB REINFORCEMENT 62-69

D. N. Acharya and K. O. Kemp—Oct. 1965, pp. 1265-1280

The neglect of the shear force on the longitudinal reinforcement (dowel force) in reinforced concrete beams without shear reinforcement is questioned. Analysis of tests on simple rectangular beams shows that the assumption of zero dowel force implies high stresses on the concrete at the top of the diagonal crack. It is suggested that the magnitude of the dowel force and its point of action are important factors in deciding the mode of shear failure of such beams.

BELL-PIER CONSTRUCTION, RECENT DEVELOPMENTS AND TRENDS 62-70

Ben C. Gerwick, Jr.—Oct. 1965, pp. 1281-1292

The "bell-pier" scheme of construction is being increasingly used for major bridge piers in deep water. This scheme has undergone considerable evolution and improvement in recent years, with better utilization of precast concrete shells, better control and quality for tremie concrete, and improved details which have greatly reduced the amount and complexity of underwater connections. This recent experience portends further developments and use. A number of these trends and potential improvements are suggested for consideration.

Adam M. Neville and Michael M. Staunton—Oct. 1965, pp. 1293-1312

Analytical and numerical methods are presented for the computation of creep of concrete when the stress-strength ratio varies with time. The computations are based on a "standard" creep curve for a concrete of constant strength.

Max R. Johnson—Oct. 1965, pp. 1313-1326

Design considerations and construction progress for the San Luis Canal in central California are described. The canal is a principal feature of a large water project being built as a joint effort of the U. S. Bureau of Reclamation and the California Department of Water Resources. It will be over 100 miles long and have an initial capacity of about 13,100 cu ft per sec when completed in 1967. An unreinforced concrete lining, 4-1/2 in. thick, was selected because of its smoothness and because it allowed a smaller cross section. Experience and economic studies showed that an appreciable saving in capital outlay and maintenance costs could be realized with such a lining.

Details of the slip-forming operation, special equipment used, and special joints developed to reduce leakage are described. Concrete mixes and aggregate gradings especially developed for slip-form paving are described.

Kenneth T. Burton—Oct. 1965, pp. 1327-1344

This paper reports load tests to failure of two wide, shallow T-beams subjected to uniform load over an 18-ft span with a negative restraint moment at one end. The beams were designed in accordance with the requirements of the ACI Building Code (ACI 318-63) for ultimate strength design. They were identical in all respects except that one of the beams had ten 7 × 1-3/8-in. ducts spaced at 12-in. centers embedded in the 7-in. T-beam flange. These ducts necessitated respacing and grouping of the shear reinforcement in that beam. Both beams failed in flexure, and the load-carrying capacity was not affected significantly by the embedment of the service ducts in the flange thickness.

ACI Committee 116—Nov. 1965, pp. 1353-1362

As part of its mission, ACI Committee 116, Nomenclature, presents the seventh published installment of a glossary of terms on cement and concrete technology. The glossary has been divided into 13 increments which are being presented to elicit discussion as they are completed, regardless of order. Following publication and discussion of the final installment, the committee will review and combine the groups for consideration as an ACI standard.

John H. McGrann—Nov. 1965, pp. 1363-1374

Describes construction features of a 3000 ft river crossing of a sewer line featuring 78 in. precast concrete pipe, and the 14,000 and 9000-ft tunnels at its ends. Pumping of the cast-in place tunnel linings is also described.

William J. Venuti—Nov. 1965, pp. 1375-1394

In this research, an investigation was made of the effect of repeated loading on the variability of fatigue life of 90 pretensioned concrete beams. A regression analysis of the fatigue data led to a linear relationship between the variables of N_p, predicted fatigue life, and R, load level. This equation was used to develop a relationship between N_p, R, and P, probability of fatigue failure, expressed in the form of the cumulative normal distribution function.

Bengt B. Broms and LeRoy A. Lutz—Nov. 1965, pp. 1395-1410

Long tensile specimens reinforced with bars in various arrangements were tested. The crack widths and the crack spacings were measured at several stress levels. The simple method previously developed for prediction of crack width and spacing in members with a single bar was extended to apply to members with multiple bars.

Short tensile members were also tested. Resin was injected into all specimens to examine the internal crack formation.

Comparison was made of the crack widths found in other investigations with the values predicted by the simple method developed.

George L. England—Nov. 1965, pp. 1411-1420

Stresses in concrete are modified by the effects of creep and shrinkage, and can be estimated only if these data are known.

A solid model which approximates the structure of concrete is proposed and is used to predict creep and shrinkage strains for concretes containing various aggregates of many mix proportions, from data relating to the constituent materials.

Model predictions are compared against experimental results and it is concluded that an advantage of the model has been its ability to predict time-dependent strains in concrete from a minimum of experimental data.

PRACTICAL ANALYSIS OF THE ANCHORAGE ZONE PROBLEM IN PRESTRESSED BEAMS* 62-79

Rolf J. Lenschow and Mete A. Sozen—Nov. 1965, pp. 1421-1440

This two-part paper presents methods for (a) the determination of transverse stresses and (b) the proportioning of transverse reinforcement in the anchorage zone of prestressed concrete beams. The methods presented are based on a physical analog representing the end of the beam. Part 1 of the paper describes the basic features of the approach, compares the results with others based on theory and experiment, develops simple design procedures, and concludes with numerical examples. Part 2 discusses in detail the derivations associated with the development of the physical analog.

A considerable amount of significant work on anchorage zone stresses has preceded this paper. The contribution of this effort is that it provides an analytical tool which can be used in design to investigate many different conditions without the necessity of laborious solutions.

CAPACITIES OF RECTANGULAR SECTION BY WORKING STRESS DESIGN 62-80

R. H. Olson and O. J. Stepanek—Nov. 1965, pp. 1441-1450

Presents tables to aid in the design of beams with and without compressive reinforcement. Tables give resisting moments for rectangular sections 12 in. wide, resisting moments for 1 sq in. of compressive reinforcement, and shear capacities for effective depth of 2 to 64 in., concrete compressive strengths of 3000, 4000, and 5000 psi and distances from the extreme compression fiber of 2 and 2-1/2 in. Examples are given to illustrate the use of the tables. The procedure can be applied to the design of T-sections under certain conditions.

PRESTRESS TRANSFER BOND OF PRETENSIONED STRANDS IN CONCRETE* 62-81

R. Stanton Over and Tung Au—Nov. 1965, pp. 1451-1460

Discusses the frictional and mechanical bond of seven-wire strands used in pretensioned concrete. The bond transfer lengths required for strands of 1/2, 3/8, and 1/4 in. nominal diameters are determined experimentally, and are found to increase considerably for strands of larger diameters.

TORONTO CITY HALL AND CIVIC SQUARE 62-82

Hedley E. H. Roy—Dec. 1965, pp. 1481-1502

Presents the design concepts and a brief description of the construction of the new Toronto City Hall and Civic Square. The two office towers are vertical cylindrical shells stiffened by vertical piers and the horizontal diaphragms of the floor construction. Between the towers, the council chamber is a prestressed conical shell supported on a cylindrical shaft. The roof of the chamber is a circular dome with a prestressed perimeter ring beam.

Because of the unusual shape of the tower structures, wind tunnel tests were performed on models; these are discussed.

STRENGTH OF PRESTRESSED CONCRETE BEAMS WITH WEB REINFORCEMENT 62-83

James G. MacGregor, Mete A. Sozen, and Chester P. Siess—Dec. 1965, pp. 1503-1520

Tests were carried out to study the effect of stirrups and draped reinforcement on the shear strength of prestressed concrete beams. Tests of 104 simply supported beams are discussed. The principal variables were the amount, type, and spacing of the stirrups and the profile of the longitudinal reinforcement. Other variables included the shape of the cross section, the prestress level, the amount of longitudinal reinforcement, the concrete strength, and the type of loading. The patterns of behavior observed in the tests are classified and compared with special attention to the manner in which inclined cracking developed and the mode of failure.

BACARDI BUILDING—AN UNUSUAL STRUCTURE FOR AN UNUSUAL BUILDING 62-84

Edwin C. Bliss and Angel Herrera—Dec. 1965, pp. 1521-1532

Describes the structure and some of the design considerations and construction aspects involved in its erection. The building surmounts an underground parking garage, the roof of which serves as a plaza and the floor to a glass-enclosed display area. The six upper floors are suspended from four stilt-like columns by post-tensioned trusses on top. The 14 × 30-in. columns were cast of high strength concrete and reinforced with A-432 steel bars. A service tower, which stands free of the structure, connects all floors to the parking garage. The two supporting trusses are formed by the roof slab and adjoining spandrel beams as the bottom chord with a 21 × 36 in. post-tensioned top chord connected with 12 × 20 in. diagonal compression members. The main vertical truss member, which is in tension, is formed by two 6 × 1-3/4 in. steel plates.

EFFECTS OF COLUMN EXPOSURE IN TALL STRUCTURES—TEMPERATURE VARIATIONS AND THEIR EFFECTS 62-85

Mark Fintel and Fazlur R. Khan—Dec. 1965, pp. 1533-1556

A design temperature is recommended for exposed concrete members based on studies of time lag, and attenuation within the member of exterior temperature amplitudes of different cycles. A graphical method is presented for rapid, accurate determination of isotherms, gradients, and average temperatures. Isotherms and gradients are included for typical exposed columns of both normal weight and lightweight concrete. The effects of bowing and length changes of partially exposed columns are discussed.

STRUCTURAL DESIGN OF THE NATIONAL STADIUM IN JAMAICA 62-86

Clifford J. Evans—Dec. 1965, pp. 1557-1566

Describes the structural design and construction of the National Stadium at Briggs Park, Kingston, which was built for the IX Central American and Caribbean Games held in Jamaica in 1962. The most interesting feature is the arch

frame cantilevered roof of the grandstand. The considerations of differential deflections, which affected the design, and methods of construction are described in detail.

CREEP OF CONCRETE AT ELEVATED TEMPERATURES 62-87

Karim W. Nasser and Adam M. Neville—Dec. 1965, pp. 1567-1580

Data on creep of concrete, both mass- and water-cured in the temperature range 70 to 205 F are presented, together with results of subsequent creep recovery tests. Hence, observations on the viscous character of the creep deformation are made. Data on strength and elasticity of one mix within the same termperature range are presented.

LOAD-SHARING PRECAST CONCRETE SLATS 62-88

Avinadav Siev and Jacob Maos—Dec. 1965, pp. 1581-1590

Precast beams used in slatted flooring in cattle sheds were heretofore designed for each to carry the whole widely-varying live load, and are both bulky and expensive as a result.

The paper presents a method for linking separate slats with a view to distributing the live load. Tests have shown that this results in sharing of the load, thereby permitting considerable saving in dimensions, weight, and reinforcement.

V.63 SYNOPSES

Institute papers and reports of Proceedings V. 63 (January-December 1966 ACI JOURNAL)

ACI Committee 302—Jan. 1966, pp. 1–58

Quality of a concrete slab or floor is highly dependent on achieving a hard and durable surface which is plane and free of cracks. The properties that the surface has are determined by the quality of the concreting operations. Furthermore, timing of these concreting operations and finishing techniques is critical. Otherwise, undesirable changes occur at the wearing surface; these may lead to soft or dusting surfaces, permeable concrete, cracking, and poor durability.

To obtain a good floor, the project specifications must cover all aspects of site preparation, concreting materials, concrete mixture proportions, concreting, workmanship, and curing. Adequate supervision and inspection are required of all job operations including particularly those of finishing.

F. S. Ople, Jr. and C. L. Hulsbos—Jan. 1966, pp. 59–82

The work described in this paper is part of a research investigation into the fatigue life of prestressed concrete flexural members where crushing of the concrete compression block precedes the fracture of the tension steel reinforcement. The results of constant load cycle tests conducted on plain concrete specimens to study the effect of compressive stress gradient on fatigue life are presented and discussed.

Application of the results of the study for estimating beam fatigue life as limited by fatigue failure of the concrete in compression is briefly discussed. An approximate design check against the possibility of concrete failure in beams subjected to repeated flexural loads is formulated for a specified fatigue life $N = 2{,}000{,}000$ cycles and probability "design limit" $P \leq 0.00001$.

Paul Rogers—Jan. 1966, pp. 83–92

Describes a large extension project to this well-known hotel in Las Vegas, Nev. Includes discussion of the design concept and construction. Reviews the investigation to determine the natural period of vibration for the hotel which is in an area susceptible to earthquakes. Remedial measures needed due to faulty construction of one of the floors are also discussed.

T. Z. Harmathy and J. E. Berndt—Jan. 1966, pp. 93–112

The stress-strain relationship in compression of hydrated portland cement (with a water-cement ratio of 0.33) and a lightweight concrete was studied at elevated temperatures. The properties of both materials seemed to be virtually unaffected by temperature up to about 400 F. Above this, the modulus of elasticity and ultimate strength decreased with increasing temperature. These changes were more definite for hydrated portland cement.

Nabil S. Hadawi and John L. Tanner—Jan. 1966, pp. 113–126

Describes the design and construction of a series of translational shells generated by arcs of circles. The shells are organized into modular bays 25 ft square. The 3 in. thick shells are supported on a series of orthogonal multispan arch frames and cover an area of 12,500 sq ft.

Mark J. Baron—Jan. 1966, pp. 127–134

The shear strength of a beam is decreased at a location where tensile steel is cut off. Test results are presented in which the addition of tensile steel terminated in the shear span resulted in reduced load capacity. The use of a bent bar instead of stopped bars was found to have no such ill effect.

ACI Committee 301—Feb. 1966, pp. 161–218

These specifications are a reference standard which the engineer or architect may make applicable to any building project by citing them in the project specifications. Individual chapters or sections should not be copied into project specifications since their meanings will be changed by taking them out of context.

The specifications need to be supplemented by designating or specifying individual project requirements. Four lists are provided listing places in these specifications and items that will require, or may require, specific treatment by the specification writer. The list of items requiring designation or specification are classed as: mandatory; additional mandatory, items designated or specified if the subject matter applies to the project; requirements at variance with these provisions; and requirements which are purely optional.

ACI Committee 506—Feb. 1966, pp. 219–246

Recommendations are given on the applicability of shotcrete to different types of construction, material require-

ments, and application procedures. Equipment requirements are given for both the dry mix and wet mix processes. The testing of shotcrete is covered in some detail.

The necessity for a well-qualified application crew is stressed.

PERFORMANCE OF ALUMINUM IN CONCRETE CONTAINING CHLORIDES 63-9

Frank L. McGeary—Feb. 1966, pp. 247–266

Results of detailed research and investigation of field problems have demonstrated that chlorides in concrete can cause severe corrosion of aluminum when coupled to steel. The expansive nature of the corrosion products causes cracking and spalling of concrete cover over embedded aluminum conduit.

Chloride anion enrichment, as a result of the galvanic connection, serves to arrest polarization of the aluminum. Production of an aluminum chlorhydroxide product and a specially oriented "cubic" attack pattern have been typical of this reaction in both field and laboratory experiences. A similar ion migration mechanism might be expected for any metal whose composition or state of stress make it anodic to other coupled embedded metals.

In chloride-free concrete, aluminum has good resistance to corrosion both alone and coupled to steel and no cracking of concrete has been encountered. It is recommended that chloride additions or contaminations should be avoided in concrete containing embedded metals. If this is not practicable, protective coatings are required and are available.

INFLUENCE OF SIZE AND SHAPE OF MEMBER ON THE SHRINKAGE AND CREEP OF CONCRETE. 63-10

Torben C. Hansen and Alan H. Mattock—Feb. 1966, pp. 267–290

With a view toward application in structural engineering, a laboratory investigation is in progress regarding the influence of size and shape of member on the shrinkage and creep of concrete. This paper reports test data obtained during the first 4 years of observation. Measurements have been made of shrinkage and creep, at 70F and 50 percent relative humidity, of concrete cylinders ranging in diameter from 4 to 24 in., and of I-shaped members with depths from 11.5 to 46 in. The creep specimens were loaded to about 25 percent of their compressive strength. It is concluded that the volume-surface ratio is a suitable parameter for use in structural design when estimating the influence of size and shape of member on shrinkage and creep deformations.

ACI STANDARD RECOMMENDED PRACTICE FOR COLD WEATHER CONCRETING (ACI 306-66). 63-11

Announcement of ACI Standard
Separate Copies of the Standard available

ACI 306-66 Superseded ACI 604-56 and Title No. 62-60

ACI Committee 306—Mar. 1966, pp. 305–306

The general requirements for producing satisfactory concrete during cold weather are discussed, as are methods for achieving these requirements. It is emphasized that for many structural concretes, protection considerably in excess of that required to insure freedom from damage by early freezing is required to assure safe development of strength. Accelerators, keeping of temperature records, heating of materials, subgrade preparation, protective insulating coverings, heated enclosures, curing, and form removal are discussed. Supplementary material on the effect of curing temperatures on concrete strength is referenced in authoritative sources. A list of selected references is included.

GLOSSARY OF TERMS ON CEMENT AND CONCRETE TECHNOLOGY—INCREMENT NO. 11 63-12

ACI Committee 116—Mar. 1966, pp. 307–312

As part of its mission, ACI Committee 116, Nomenclature, presents the eighth and last published installment of a glossary of terms on cement and concrete technology. The glossary has been divided into 13 increments which are being presented to elicit discussion as they are completed, regardless of order. Following discussion of this final installment, the committee will review and combine the groups for consideration as an ACI standard.

SCALLOPED PRESTRESSED DOME FROM PRESTRESSED ELEMENTS 63-13

Horst Berger—Mar. 1966, pp. 313–324

Precast and cast-in-place reinforced concrete are used to frame the main roof structure of the University of Virginia's new Field House. Precast elements are cast on site. Cast-in-place concrete and post-tensioned dowels provide monolithic behavior. The tension ring is post-tensioned by a wire wrapping system. Design and construction of this dome structure are described.

CONTRIBUTION OF LONGITUDINAL STEEL TO SHEAR RESISTANCE OF REINFORCED CONCRETE BEAMS. 63-14

William J. Krefeld and Charles W. Thurston—Mar. 1966, pp. 325–344

An hypothesis of the mechanism of shear failure of reinforced concrete beams is developed from studies of the behavior of several conventional beams tested with special instrumentation, and of a number of beams especially constructed to show the contributing resistance to external shear of the longitudinal steel acting in conjunction with the embedding concrete. Some data are provided to show the effects of bar size, bar spacings, depth of cover below the bars, and concrete strength on such dowel resistance.

CONNECTIONS IN PRECAST CONCRETE CONSTRUCTION 63-15

Philip W. Birkeland and Halvard W. Birkeland—Mar. 1966, pp. 345–368

Outlines and discusses requirements for connections in precast concrete buildings, and shows examples from completed structures where these requirements have been met. A time-proven hypothesis explaining shear behavior at concrete to steel and concrete to concrete interfaces is presented. Examples illustrate beam to column connections using this hypothesis. Suggestions for further study are outlined.

PARTICLE INTERFERENCE AND THE WORKABILITY OF CONCRETE* 63-16

Barry P. Hughes—Mar. 1966, pp. 369–372

Considers the factors which affect the optimum coarse aggregatecontent in proportioning a concrete mix. Weymouth's theory of particle interference, as extended by Butcher and Hopkins, is examined and further modified.

TIME-DEPENDENT DEFLECTIONS OF REINFORCED CONCRETE BEAMS* . . . 63-17

William G. Corley and Mete A. Sozen—Mar. 1966, pp. 373–386

Reports the observed deformations of four beams over a period of 2 years and presents a simple method for estimating the time-dependent deflections of reinforced concrete beams.

POST-TENSIONED CAST-IN-PLACE MULTISTORY BUILDING FRAME 63-18

Walter E. Riley—Mar. 1966, pp. 387–404

The use of post-tensioned construction is described for a cast-in-place multistory building frame. The design of a typical floor girder 27 in. deep spanning 64 ft is given. The flexibility of the concrete shear walls is discussed and the resulting loading on the transverse and exterior longitudinal frames is described. Construction procedures and special operations are reviewed.

CONSTRUCTION OF THE ACCELERATOR HOUSING AT THE STANFORD LINEAR ACCELERATOR CENTER 63-19

Everette W. Osgood and James M. Keith—Apr. 1966, pp. 425–440

The reinforced concrete housing for the linear electron accelerator had unusually severe requirements for dimensional stability. These special requirements resulted in a "tailored" structural concrete specification with particular emphasis placed on temperature control, shrinkage, and quality.

Included is a brief description of the preliminary concrete investigations and the concrete specification highlights. The construction methods, quality control, properties of the concrete, recent dimensional changes in the structure, cracking, and epoxy injection are discussed.

PARTIALLY COMPACTED WEIGHT OF CONCRETE AS A MEASURE OF WORKABILITY* 63-20

Bryant Mather—Apr. 1966, pp. 441–450

A study of the compacting-factor method of measuring workability of small-aggregate concrete (1 ½ in.) indicated that: (a) the degree to which concrete heaps when a mold is allowed to overfill from the discharge of a mixer reaches a maximum at an intermediate workability and decreases as the mixture gets either drier or wetter; and (b) the net, loose weight of concrete in a mold after strike off increases with increasing workability. The net, loose weight of concrete in a mold filled to overflowing and then struck off could form the basis for controlling workability of mixtures having a slump not greater than 3 in. Studies using mixtures with 6-in. aggregate indicated that heaping weight, struck-off weight, and compacting factor increase with increased water content until the slump reaches from 1 ½ to 3 in. and then they decrease. Routine determinations of heaping weight or struck-off loose weight might be used to detect batches of excessive or deficient water content which could be rejected before delivery to the forms.

STUDIES OF THE SHEAR AND DIAGONAL TENSION STRENGTH OF SIMPLY SUPPORTED REINFORCED CONCRETE BEAMS 63-21

William J. Krefeld and Charles W. Thurston—Apr. 1966, pp. 451–476

This investigation, involving the testing of over 200 reinforced concrete beams subjected to concentrated and distributed loads, contributes useful data on shear resistance. Observations and conclusions are based on the effects of the primary variables of test, namely, concrete strength, steel ratio, span length, and two types of loading on simply supported beams with and without stirrups. Formulas for estimating the critical shear intensity in terms of known parameters and empirically determined constants are developed from an hypothesis of the mechanism of shear failure which was presented in an earlier paper. Information is given on the reserve strength of some beams beyond the critical shear intensity.

STRUCTURAL DESIGN AND CONSTRUCTION FEATURES OF OUR LADY OF GOOD COUNSEL. 63-22

S. Don Shimazu—Apr. 1966, pp. 447–488

Describes the use of precast elements, some prestressed, in the construction of a 12 classroom, 3 story school building. The precast elements were cast off the site with maximum form reuse and delivery programed with site operations. The precast frame for the two wings of the L-shaped structure, about 135 × 99 ft each, was erected in about 4 days. Roof and floor slabs were cast in place, beginning at the top and working down by dropping the formwork in complete bay assemblies.

TEMPERATURE CHANGE EFFECT ON BEHAVIOR OF CEMENT PASTE, MORTAR, AND CONCRETE UNDER LOAD. 63-23

Torben C. Hansen and Leif Eriksson—Apr. 1966, pp. 489–504

Presents results of an experimental study of the effect of temperature changes between room temperature and 212 F on deflections of cement paste and mortar beams under load.

It was found that: (a) cement paste and mortar beams deflect excessively when heated after application of load; (b) deflections occasionally lead to failure at low stresses and after moderate heating; (c) deflections increase with increasing rate of heating; (d) deflections are larger and the temperature at failure is lower for cement paste than for cement mortar; (e) deflections are larger and the temperature at failure is lower for saturated than for dry beams; (f) rapid rates of heating permanently reduces the modulus of elasticity of cement mortar, indicating internal destruction of the material structure; (g) thermal cycling leads to excessive deflections and occasionally to failure.

A tentative explanation of the phenomena observed is suggested.

ACI IN THE SERVICE OF MANKIND . . 63-24

A. Allan Bates—May 1966, pp. 521–526

Retiring ACI President A. Allan Bates—chief, Division of Building Research, National Bureau of Standards, Washington, D.C.—discusses ACI's progressive strides during the past year and the world-wide scope of future Institute activities.

PUNCHING STRENGTH OF REINFORCED CONCRETE SLABS* 63-25

David Yitzhaki—May 1966, pp. 527–542

A method of evaluation of the punching strength of reinforced concrete slabs is presented and the correlation between punching resistance and flexural strength clearly established. The punching resistance depends mainly on the reinforcement strength as in the case of flexural strength. It is shown that the effect of the concrete on punching resistance is of the same order of magnitude as it is on the flexural strength and can be expressed by the factor $1 - q/2$ used in the analysis of the ultimate flexural strength of reinforced concrete members. The theory is substantiated by test data.

The effectiveness of bending up a part of the flexural reinforcement is discussed. It is proved by a series of tests that by bending up a part of the flexural reinforcement the punching strength of flat slabs can be secured.

The method is directly applicable to the design of the column region of flat slabs and suitable charts are provided.

LINING OF THE MCCLOUD-PIT TUNNELS 63-26

G. E. Broderson and W. K. Flint—May 1966, pp. 543–552

Describes and illustrates the construction phase of the tunnels on a hydroelectric project in Shasta County, California. Traces the concrete operation through mix proportioning, mixing, transportation, and placing. Illustrations of specialized transporting and handling equipment are presented.

MODEL STUDY OF HYPERBOLIC PARABOLOID SHELLS 63-27

P. Dayaratnam, V. Jagannadharao, and S. Pradhamam—May 1966, pp. 553–570

Three thick concrete hyperbolic paraboloid shells supported on elastic edge beams were tested. The shells were tested for vertical deflections for uniformly distributed loads and bending moments at various sections were calculated. A comparative study of bending moment profiles and bending moment contours of the shells is presented. Deflections and bending moments at various points of one of the shells for horizontal movement of the top of the short columns along the line joining the columns are also given. A comparison of maximum deflections and maximum positive bending moments of the shells was made with plates of similar sections supported on elastic edge beams.

YIELD ANALYSIS OF BALCONY FLOOR SLABS 63-28

Kuang-Han Chu and Ram B. Singh—May 1966, pp. 571–586

Studies are made of uniformly loaded rectangular slabs with two adjacent free edges and rectangular and trapezoidal slabs with the base edge free as used for balcony slabs. Formulas for ultimate load based on yield line theory are derived and moment coefficients for typical cases are presented.

EXPERIMENTAL STUDY OF A FREE-STANDING STAIRCASE 63-29

A. R. Cusens and Jing-Gwo Kuang—May 1966, pp. 587–604

Describes the loading tests to failure on a half-scale model of a symmetrical reinforced concrete slab-type, free-standing staircase. Methods of analysis are compared in the light of experimental results and general design recommendations are made.

PROPOSED ACI STANDARD RECOMMENDED PRACTICE FOR MANUFACTURED REINFORCED CONCRETE FLOOR AND ROOF UNITS 63-30

ACI-ASCE Committee 512—June 1966, pp. 625–636

Recommendations are made for the design, manufacture, and erection of precast reinforced concrete floor and roof units having spans of 35 ft (11 m) or less. Unit stress, ultimate strength, and a test method of strength design are recommended. Recommendations are made regarding bearing lengths, bar spacings, minimum reinforcement, and holes. Quality requirements and acceptance procedures are discussed. Prestressed concrete members are not covered in the report.

DEFLECTIONS OF REINFORCED CONCRETE FLEXURAL MEMBERS 63-31

ACI Committee 435—June 1966, pp. 637–674

Discusses the principal factors affecting short-time and long-time deflections of reinforced concrete flexural members. Several methods for computing deflections are reviewed and a study made of the accuracy of these methods for predicting initial and time-dependent deflections.

BASIC FACTS CONCERNING SHEAR FAILURE* 63-32

G. N. J. Kani—June 1966, pp. 675–692

Reports on tests of rectangular beams performed to determine the influence of the three basic parameters in Eq. (12-2) and (17-2) of ACI 318-63. The results showed: (1) The influence of compressive strength, f'_c, on so-called shear strength was insignificant and could be ignored in the analysis of diagonal failure load or allowable shear stress. (2) The influence of the percentage of main reinforcement, p, on "shear strength" was considerable. (3) The minimum value of bending moment at failure for beams of identical cross section was obtained in the vicinity of a shear arm ratio, a/d, of 2.5, and this was not influenced by p or f'_c. However, flexural load capacity varied considerably with percent of main reinforcement. (4) There exists a clearly defined region bounded by limiting values of p and a/d inside which diagonal failure is imminent and outside which full flexural strength is attained.

CHARTS FOR THE WORKING STRESS DESIGN OF REINFORCED CONCRETE BEAMS 63-33

B. W. Shirwaikar—June 1966, pp. 693–700

Charts are presented for the working stress design of beams in accordance with ACI 318-63

The design of singly-reinforced and doubly-reinforced sections is covered by the charts, wherein the amount of tension and compression reinforcement can be read.

ACI STANDARD SPECIFICATIONS FOR STRUCTURAL CONCRETE FOR BUILDINGS (ACI 301-66) 63-34

Announcement of ACI Standard
Separate Copies of the Standard available

Supersedes Title No. 63-7

ACI Committee 301—July 1966, pp. 729–731

These specifications are a reference standard which the engineer or architect may make applicable to any building project by citing them in the project specifications. Individual chapters or sections should not be copied into project specifications since their meanings will be changed by taking them out of context.

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RECOMMENDED PRACTICE FOR SHOTCRETING (ACI 506-66) 63-35

Announcement of ACI Standard
Separate Copies of the Standard available

Supersedes ACI 805-51 and Title No. 63-8

ACI Committee 506—July 1966, p. 732

Recommendations are given on the applicability of shotcrete to different types of construction, material requirements, and application procedures. Equipment requirements are given for both the dry mix and wet mix processes. The testing of shotcrete is covered in some detail.

The necessity for a well-qualified application crew is stressed.

ITERATIVE SOLUTION FOR ARCHED FRAMES SUPPORTING SHELLS* 63-36

Arnold Winokur and Amnon Bloch—July 1966, pp. 733–742

Presents an iterative method for the analysis of arched frames (or gables) which support shells. These gables differ from ordinary frames in their curved shape and in the way they receive load from the shells. Every continuous gable can be divided into "elementary" frames, having only one joint which is free to move. The method presented, which analyzes the whole frame, makes use of stiffness and carry-over factors, which are easily calculated. The solution is achieved in one operation, in which all moments, as well as all horizontal forces produced at the joints, are balanced. As a result there is no need to set up equations for horizontal displacements. This is important because the degree of freedom for displacement is high with arched frames. Using this method, the real moments and axial forces acting in the continuous gable under various load can be determined, and the eccentricity existing between the shell and gable taken into account.

MEASURING THE THICKNESS OF A CONCRETE SLAB BY GAMMA RAY TRANSMISSION 63-37

Kenneth Preiss—July 1966, pp. 743–748

Describes a method for determining the thickness of a concrete slab by measuring the amount of gamma radiation that passes through it. Results in the laboratory showed that slabs could be measured to an accuracy of better than 2 percent.

DIRECT SOLUTION FOR BOND REQUIREMENTS AT REINFORCING BARS 63-38

Willy K. Hahn—July 1966, pp. 749–754

The limits given in Chapter 13 of ACI 318-63 establish a definite relation between the flexural bond stress formula, Eq. (13-1), and bar diameters. Bond coefficients for available bar sizes, bar deformations, and concrete grades are presented to facilitate simple bond computations.

INVESTIGATION OF A REACTION INVOLVING NONDOLOMITIC LIMESTONE AGGREGATE IN CONCRETE* 63-39

Alan D. Buck and W. L. Dolch—July 1966, pp. 755–766

A laboratory investigation was made of a chemical reaction observed as rims on nondolomitic limestone coarse aggregate particles in field concrete. The rims were characterized by a color variation and an increased solubility in acid.

Seventeen limestones from 11 sources were used. The reaction was developed in three of the rocks in laboratory test specimens; x-ray diffraction analysis led to a tentative explanation.

It was concluded that this reaction could occur with all carbonate rocks in concrete and could contribute to aggregate-paste bond.

ULTIMATE LOAD CAPACITY OF PRESTRESSED CONCRETE COLUMNS . . 63-40

Paul Zia and F. L. Moreadith—July 1966, pp. 767–788

Presents the results of an analytical study on the load carrying capacity of rectangular prestressed concrete columns with hinged ends. The effects of concrete strength, steel percentage, slenderness ratio and eccentricity on the strength of columns are investigated. Comparison is made between the strength of prestressed concrete columns and that of reinforced concrete columns. The results indicate that the advantage of prestressing lies with the slender columns subject to loads with large eccentricity. On the basis of the results obtained, simple design procedures are proposed. The procedures are similar to the current design method for reinforced concrete columns in that the strength of short columns is modified by capacity reduction factors to account for the effects of slenderness ratio and eccentricity.

AUTOCLAVE CURING OF CONCRETE IN SOVIET UNION AND UNITED STATES 63-41

George L. Kalousek—Aug. 1966, pp. 817–834

The apparent differences in the autoclaved concrete industries in the Soviet Union and the United States are attributed to the different needs, raw material availabilities and end usage in the two countries. Drying cracking of concrete masonry gave impetus to autoclave curing in the United States to alleviate the problem. In the Soviet Union, shortage of cement and abundance of calcareous and siliceous materials, and urgent need of housing were factors leading to high pressure steam curing on a big scale. The most important property after strength in the Soviet Union is resistance to frost deterioration and, in the United States, to shrinkage cracking. The Soviets are highly research oriented with considerable emphasis on fundamentals.

BEHAVIOR OF PRESTRESSED CONCRETE BEAMS UNDER SIMULATED MOVING LOADS 63-42

James G. MacGregor, Chester P. Siess, and Mete A. Sozen—Aug. 1966, pp. 835–842

Seven simply supported prestressed concrete beams were tested under a moving load simulated by the application of a single concentrated load successively at 11 load locations uniformly spaced along the span. The magnitude of the moving load was increased after each traverse of the span.

The development of flexural and inclined cracking was similar to that in beams tested under stationary loads and the empirical expressions presented in an earlier paper to predict inclined cracking and ultimate loads for prestressed beams were found to apply to the case of moving loads.

EFFECT OF COLUMN EXPOSURE IN TALL STRUCTURES—ANALYSIS FOR LENGTH CHANGES OF EXPOSED COLUMNS . . 63-43

Fazlur R. Khan and Mark Fintel—Aug. 1966, pp. 843–864

Develops a generalized method of analysis for multistory frames for length changes of exposed columns. A simplified method is then presented for quick, and relatively accurate, solution. Design curves representing a wide range of practical column-to-beam proportions are included. These curves are intended to be used for preliminary design, and in many cases for the final design of the structure. Finally, design stresses, behavior of partitions, and limitations of movement are discussed.

BOND STRESS DISTRIBUTION ON REINFORCING STEEL IN BEAMS AND PULLOUT SPECIMENS 63-44

Ervin S. Perry and J. Neils Thompson—Aug. 1966, pp. 865–876

The distribution of steel stress and bond stress along a reinforcing bar was investigated in eccentric pullout specimens and in beams at a crack and at a bar cutoff. Comparisons are made of bond stress in all three cases. Even though little similarity in bond stress distributions was found in the three types of specimens, approximately the same maximum bond stress was developed at some point for equal steel stresses: (a) at the loaded end of the pullout specimen, (b) at the crack in a beam, and (c) at a distance from the bar cutoff point equal to the length of the pullout specimens.

CONCRETE PROPORTIONING AND CONTROL FOR THE "SKYLON" 63-45

L. R. Lauer and R. J. Rigby—Sept. 1966, pp. 897–910

Reports on the concrete quality control procedures for the "Skylon Tower" of the Niagara International Centre, Niagara Falls, Ontario, Canada. The procedures use a graphical method to determine mean strength, standard deviation, and coefficient of variation and its application to the mixes used on the project. The graphical method is compared with ACI 214-65.

The ready-mixed concrete supplier first established the efficiency of two batching plants which would supply concrete to the project, based on past concrete cylinder compression test results. Two different classes of concrete were used, requiring separate preliminary mix proportioning programs. Plant efficiencies were determined for each concrete section and adjustments made as warranted in succeeding concrete sections to effect maximum economies while maintaining specified performance.

CAPACITY OF REINFORCED RECTANGULAR COLUMNS SUBJECT TO BIAXIAL BENDING 63-46

Alfred L. Parme, Jose M. Nieves and Albert Gouwens—Sept. 1966, pp. 911–924

Comprehensive design charts complying to Section 1905 (a) of the ACI Building Code (318-63) relating the biaxial bending capacity of rectangular columns to the uniaxial bending capacity by a single parameter are presented. Differences in the behavior of columns due to bar arrangement and steel strengths are noted. An approximate procedure which facilitates the determination of the required size for columns subject to biaxial bending is suggested and evaluated.

INELASTIC BEHAVIOR AND FRACTURE OF CONCRETE* 63-47

Surendra P. Shah and George Winter—Sept. 1966, pp. 925–930

Elements of a unified theory of the mechanical behavior of concrete, from no-load to fracture under short-time loading, are developed, based o... bserved microcrack behavior and on a statistical distribution of mortar strength.

SLIP FORM CONSTRUCTION OF CEMENT STORAGE SILOS 63-48

A. M. Liberati—Sept. 1966, pp. 931–940

The slip form construction of the cement storage silos for the Alpha Cement Co. at Catskill, N.Y., is described. The project consists of a battery of eight U-shaped silos which, in addition, form part of the wall of a storage hall for clinker and raw material. The semi-enclosed hall is 360 ft long by 100 ft center-to-center of crane rails. The major part of the hall is formed by 69 ft free-standing columns which were also cast in sliding forms.

The major construction problems were maintaining vertical alignment of the columns and casting the varying cross section of the silos as concreting progressed upward.

SUGGESTED DESIGN PROCEDURES FOR COMBINED FOOTINGS AND MATS. . . 63-49

ACI Committee 436—Oct. 1966, pp. 1041–1058

This report deals with the design of footings carrying more than a single column or wall load. Although it is primarily

concerned with the structural aspects of the design, considerations of soil mechanics cannot be eliminated and the designer's attention is invited to the important interrelation of the two fields in connection with the design of such construction elements.

FATIGUE STRENGTH OF CONCRETE UNDER VARYING FLEXURAL STRESSES 63-50

Hubert K. Hilsdorf and Clyde E. Kesler—Oct. 1966, pp. 1059–1076

Previous fatigue studies of concrete were in many cases not representative of the load conditions of actual structures since in these tests the applied loads fluctuated between constant minimum and maximum values. In the present investigation plain concrete specimens were subjected to repeated flexural stresses according to various load histories; the maximum load within a test was varied between two limits, or rest periods were introduced. The results were interpreted according to various physical models and compared to the Miner rule. This hypothesis may give conservative or unsafe predictions of the fatigue strength depending on the load program. An improved design method is suggested.

RATIONAL APPROACH TO PLATE DESIGN* 63-51

G. I. N. Rozvany—Oct. 1966, pp. 1077–1094

Recently developed optimum design methods for reinforced concrete plates and prestressed plates are outlined, and simplified methods for determining the cracking load and ultimate load for optimized prestressed plates are presented. The proposed methods are compared with other design techniques.

A GENERAL RELATION FOR STRENGTHS OF CONCRETE SPECIMENS OF DIFFERENT SHAPES AND SIZES 63-52

Adam M. Neville—Oct. 1966, pp. 1095–1110

It is shown that the strengths of concrete test specimens (cylinders, cubes, and prisms) can be related to one another by simple expressions. Substantiating test results are presented. The secondary influence of the fineness modulus of aggregate on this relation is discussed.

BOND STRESS—THE STATE OF THE ART. 63-53

ACI Committee 408—Nov. 1966, pp. 1161–1190

The nature of bond failure is discussed and the influence of splitting is emphasized. The large bond stresses adjacent to any crack and the complications caused by this "out-and-in" bond are emphasized. Factors influencing splitting and the weak planes in splitting are related. The importance of beam width or bar spacing on bond resistance is developed. The concepts of end anchorage, flexural bond, and anchorage or development bond are contrasted.

Present knowledge of bond behavior and the absolute value of bond resistance are reviewed, first in terms of splices and special members, and then in the negative movement region of a beam. Some of the data justifying the 1963 Building Code provisions are presented. The value of end anchorage is indicated and the importance of development bond or development length is emphasized.

The effect of top bar position and the influence of lightweight concrete are briefly discussed. Finally, weak spots in existing knowledge and areas needing further investigation are mentioned.

SIZE EFFECT IN SMALL-SCALE MODELS OF REINFORCED CONCRETE BEAMS* . . . 63-54

William A. Litle and Mario Paparoni—Nov. 1966, pp. 1191–1204

An experimental study of the influence of geometric scale on the ultimate strength of reinforced mortar beams failing in a flexural mode is presented. In the test were 132 beams, which included five different geometric scale ratios and two reinforcement ratios. Evidence of a significant relative increase in strength for the smaller specimens was found. Some potential causes for these increases are postulated and examined.

ULTIMATE STRENGTH DESIGN CHARTS FOR COLUMNS WITH BIAXIAL BENDING . . 63-55

Donald C. Weber—Nov. 1966, pp. 1205–1230

The problem of combined biaxial bending and axial compression of short rectangular columns is discussed. A method of approximating the failure surface based on linear interpolation between the capacity for bending on the diagonal and the capacity for bending on a principal axis is proposed. Design charts for columns with equal bending resistance on both principal axes and examples to illustrate their use are included.

TIME DEPENDENT LOAD TRANSFER IN REINFORCED LIGHTWEIGHT CONCRETE COLUMNS 63-56

Thomas A. Holm and Joseph Pistrang—Nov. 1966, pp. 1231–1246

Time-dependent strains of an axially loaded, structural size, reinforced lightweight concrete column were observed for 1 year to verify a theoretical method of predicting the load transfer from concrete to reinforcing steel caused by creep and shrinkage. The method, which modifies "classical" equations by considering the interaction between creep and shrinkage, was verified within engineering tolerances. It provides an adequate means of predicting long term column deformations and load transfer using, as a basis, creep and shrinkage data from plain concrete cylinders.

SHRINKAGE AND CRACKING OF CEMENT MORTARS USED FOR EXTERIOR COATING 63-57

Ori Ishai and Nathan Bavli—Nov. 1966, pp. 1247–1264

Deals mainly with the effect of curing and preliminary treatment on the relevant properties of mortar coatings, viz., strength, absorption, and, in particular, shrinkage, and cracking resistance. Results of the laboratory test series indicate the superiority of steam curing over water curing as regards shrinkage and cracking time. Other results point up the advantage of efficient mix compaction, using sand of high fineness modulus, and the effect of sealing as appropriate means for producing more cracking resistant mortar coatings.

Analysis of the results confirm the expected correlation between increased cracking resistance, on the one hand, and higher strength and lower free shrinkage, on the other.

Paul W. Abeles—Nov. 1966, pp. 1265–1278

The paper shows the application of photoelastic coating (also called photostress method) to a concrete beam, reinforced with two nontensioned prestressing strands, so as to illustrate micro and visible cracking. Deflections and crack widths at the tensile face and at the level of the steel are shown and photostress pictures are presented at various loadings, depicting the cracking during three loading cycles. The effect of an excellent bond between the steel and the high strength concrete is illustrated. A comparison is made with a concrete beam of the same dimensions but reinforced with four nontensioned prestressing wires, with which the bond conditions are quite good but not so excellent as with strands.

ACI Committee 515—Dec. 1966, pp. 1305–1392

The resistance of concrete to chemical attack may often be enhanced or maximized by careful attention to concrete proportioning, mixing, placing, and curing procedures. However, in a number of situations concrete must be protected by barrier materials which prevent contact with the chemical agent. Materials available for protection have been classified here, and tables have been provided as a guide for protection against specific agents. Methods of application, with consideration for both effectivenss and safety, are discussed. The report is intended to serve as a guide prior to consultation with experts regarding the specific situation.

William Schmidt—Dec. 1966, pp. 1393–1400

A design for a multistory building using the same slab thickness for every floor, the same size of columns in all stories, and shear walls to the height required by the designer represents a remarkable approach to the assembly line factory methods in the construction industry. Remarkable economies can be achieved when the work is done by a contractor who has great organizing talents.

Stanley G. Hutton and Robert E. Loov—Dec. 1966, pp. 1401–1410

Fully prestressed, partially prestressed, and conventionally reinforced concrete beams of the same size and virtually the same ultimate capacity were loaded to failure. Deflections and strain were measured during a storage period of approximately 4 months. Loads, deflections, strains, and maximum crack widths were measured during testing.

The wide range of behavior of reinforced concrete (the limits of which are represented by fully prestressed and conventionally reinforced concrete) that may be obtained by varying the prestressing force is illustrated.

Jiri Hosek—Dec. 1966, pp. 1411–1424

The aim of these experiments was to contribute to the understanding of the mutual influence of polymer and cement during the hardening of this combined system. Polyvinylacetate as water-emulsion was chosen as representative of polymers for all experiments.

This paper deals with the results of the experiments with polyvinylacetate-modified cement mortars; the effects of polymer admixtures on compressive, tensile, and flexural strength; on modulus of elasticity; the effect of relative humidity; and of polymer plasticizer on shrinkage. The dependence of strength on dimension of test specimens and the behavior of this mortar in water exposure and in weatherometer, rapid-cycle exposure are discussed.

Consideration of the results suggests fundamental ideas about the structure formation of polymer-cement mixtures.

Kuang-Han Chu and Omar F. Afandi—Dec. 1966, pp. 1425–1448

Formulas based on the theory of plates are presented for the computation of moments and shears in circular and annular slabs for chimney foundations. The slab is assumed to be of constant thickness, either simply supported or fixed at the chimney wall. Foundation pressure is assumed to vary linearly and exist over all portions of the slab. Results for some typical cases are presented in charts.

V.64 SYNOPSES

Institute papers and reports of Proceedings V. 64 (January-December 1967 ACI JOURNAL)

STRUCTURAL BEHAVIOR OF PRECAST CONCRETE TUNNEL LINERS 64-1

William L. Gamble—Jan. 1967, pp. 1–11

Structural tests were conducted on precast concrete segmental tunnel liners considered for use in subway tunnels of the San Francisco Bay Area Rapid Transit District. Each tunnel liner ring consisted of seven segments which formed 30 in. of circular tunnel liner when bolted together. Two liner rings were tested, with loads applied to the outer surface of the rings at 12 points.

The behavior of the rings was good. At the maximum load levels attainable, only a small amount of cracking had occurred. The acceptance criterion was that the rings should deflect at least 1 in. without visible damage. Both reached 2.5 in. deflection without appreciable damage.

ANALYSIS OF RESTRAINED REINFORCED CONCRETE COLUMNS UNDER SUSTAINED LOAD 64-2

Robert F. Manuel and James G. MacGregor—Jan. 1967, pp. 12–24

The primary objective of this investigation was the derivation of a method of analysis which can be used on a computer to determine the behavior of columns in reinforced concrete frameworks under sustained load. The method of analysis applied discreteness to the cross sections, the member lengths, and the duration of sustained load, and utilizes numerical integration and trial and error procedure to obtain equilibrium configurations of the frameworks under load. A nonlinear stress-creep strain function was considered using the rate of creep method to estimate the creep of the concrete under variable stress.

The applicability of the analysis was partially verified by comparison with experimental data reported by various investigators. The analysis was used to study the sustained load behavior of two series of laterally restrained beam column frames and the results were compared to three building codes.

BEHAVIOR AND DESIGN OF LARGE OPENINGS IN REINFORCED CONCRETE BEAMS 64-3

Karim W. Nasser, A. Acavalos, and H. R. Daniel—Jan. 1967, pp. 25–33.

A theoretical approach is outlined for the behavior of rectangular reinforced concrete beams with large openings. Results of pilot, full-size beam tests are presented and compared with the behavior of an identical beam having no openings.

VOLUME CHANGES ON SETTING AND CURING OF CEMENT PASTE AND CONCRETE FROM ZERO TO SEVEN DAYS 64-4

Floyd O. Slate and Ramon E. Matheus—Jan. 1967, pp. 34–39

Unrestrained bulk volume changes were measured by displacement of liquids in which the specimens were submerged. Cement paste and concrete stored under water from the time of molding always showed volume increases of from 0.1 to 1.5 percent, with almost the entire change occurring during the first day. Cement paste and concrete immersed in mineral oil, to prevent gain or loss of water, always showed by 7 days volume decreases of from 0.6 to 1.7 percent, with a decreasing rate of change throughout the 7 day period (cement pastes, but not concretes, showed expansion up to 6 hr or even up to 1 day, followed by contraction). When a calcium sulfoaluminate expansive compound was added, expansion was increased for both cement paste and concrete under water, no change occured for concrete under mineral oil, and greater initial expansion followed by greater contraction occurred for cement paste under oil.

EXPERIMENTS ON THE YIELD CRITERION OF ISOTROPIC REINFORCED CONCRETE SLABS 64-5

C. T. Morley—Jan. 1967, pp. 40–45

Information on the shape of the yield criterion for isotropic reinforced concrete slabs under biaxial moments is obtained from experiments on model rhomboid slabs. The results support Johansen's proposed square criterion, and also the hypothesis that kinking of steel across cracks is not significant. A method is developed for predicting the main features of the moment-curvature curves for slabs under a given combination of bending moments, from the properties of the steel and the concrete.

STRESSES AND DEFLECTIONS IN COUPLED SHEAR WALLS 64-6

Alexander Coull and J. R. Choudhury—Feb. 1967, pp. 65–72.

Curves are presented for the rapid evaluation of the stresses and maximum deflections in any system of coupled shear walls. The curves are derived from the continuum theory, in which the discrete system of connecting beams is replaced by an equivalent continuous medium.

MORTAR MODEL TEST ON A CYLINDRICAL SHELL OF VARYING CURVATURE AND THICKNESS 64-7

Arthur W. Hedgren, Jr. and David P. Billington—Feb. 1967, pp. 73–83.

Describes a test on a reinforced mortar model of a parabolic cylindrical shell with variable thickness. Deflections and strains were measured for 16 increments of vacuum loading up to failure. Experimental results indicated satisfactory model performance because of the close correlation with theoretical predictions in the working load range. The model exhibited a high safety factor against structural failure. Approximate analyses are presented for the shell diaphragm interaction and for the inelastic shell behavior after cracking and after local yielding.

CURING EFFECTS ON EXPANSION AND MECHANICAL BEHAVIOR OF EXPANSIVE CEMENT CONCRETE 64-8

Vitelmo V. Bertero—Feb. 1967, pp. 84–96

Reports the results obtained in two investigations on uniaxially restrained prismatic expansive cement concrete specimens. The object was to find out how the expansion and mechanical behavior of expansive concrete are affected by curing age and by delay in water curing.

Curing age—The mechanical characteristics of expansive cement concrete appear to be affected by the curing

age in a manner different from that experienced with conventional concrete. Results show that there is a considerable drop in strength and stiffness after a certain age. The main reason for this drop appears to be the large transverse expansion that occurs after 12 days. Results also indicate that the initial power of expansion of the concrete mix used is considerably affected by the age of the expansive component.

Delay in water curing—Histories of longitudinal and transverse expansion during curing, as well as stress-strain relationship of concrete during compressive tests, indicate that by delaying water curing (1) longitudinal and transverse expansion stops by 24 hr, (2) loss in final longitudinal and transverse expansion is small, and (3) compressive strength is not affected, but stiffness is reduced.

CREEP OF OLD CONCRETE AT NORMAL AND ELEVATED TEMPERATURES 64-9

Karim W. Nasser and Adam M. Neville—Feb. 1967, pp. 97–103

Data on creep of concrete loaded at 1 and 50 years at temperatures ranging from 70 to 205 F are presented. The pattern of the creep-time relation is shown to be the same in all cases. Influence of the temperature of storage preceding the application of load on creep is reported.

RATIONAL PROPORTIONING OF PREFORMED FOAM CELLULAR CONCRETE 64-10

Fred C. McCormick—Feb. 1967, pp. 104–110

Presents a proportioning procedure for semistructural cellular concrete which limits wet density deviation to within 5 percent of design values. Reports laboratory studies of the effects of certain mix parameters on some properties of the hardened concrete.

SAND REPLACEMENT IN STRUCTURAL LIGHTWEIGHT CONCRETE-SINTERING GRATE AGGREGATES 64–11

Donald W. Pfeifer and J. A. Hanson—Mar. 1967, pp. 121–127

Describes effects of replacing the fines of three structural lightweight aggregates with equal volumes of natural sand. This investigation is a continuation of previous work and extends test data to broaden information about aggregates produced on a sintering grate.

The results illustrate improvements in both the plastic and hardened concretes. The water and cement contents required decreased with increasing natural sand content. Physical properties of the hardened concretes were significantly improved, though the unit weights were increased moderately.

HOW SAFE ARE OUR LARGE REINFORCED CONCRETE BEAMS? 64-12

G. N. J. Kani—Mar. 1967, pp. 128–141

To answer this question, four series of test beams, with depths of 6, 12, 24, and 48 in., were tested at the University of Toronto and the results compared. Considerable influence of the absolute depth became apparent to such an extent that the safety factor for the largest beams was approximately 40 percent lower than the otherwise similar small beams. This trend indicates that, with a further increase in depth, a correspondingly further decrease in the safety factor can be expected.

EXPERIMENTAL STUDY OF MODEL COMPOSITE FLOORS 64-13

Franklin K. C. Wong and Fung-Kew Kong—Mar. 1967, pp. 142–151.

Reports on tests on six model composite floors of a wide range of transverse stiffness. Test results regarding second moments of area, composite action in longitudinal and transverse directions, and ultimate strengths were studied with reference to the 1960 tentative recommendations of ACI-ASCE Committee 333 and to British Code CP 117: 1965.

FINITE ELEMENT ANALYSIS OF REINFORCED CONCRETE BEAMS. 64-14

D. Ngo and A. C. Scordelis—Mar. 1967, pp. 152–163

The basic concept of using the finite element method of analysis in constructing an analytical model for the study of the behavior of reinforced concrete members is discussed. The finite elements chosen to represent the concrete, the steel reinforcement, and the bond links between the concrete and the steel reinforcement are described. Several examples of singly reinforced concrete beams on simple supports with different idealized cracking patterns are analyzed and results are presented for comparison and discussion. The effect of the assumed stiffness of the bond links is also examined briefly. No general conclusions regarding the behavior of the reinforced concrete beams under load are attempted in the present investigation. The purpose of the paper is to demonstrate the feasibility and to explore the potentialities as well as the difficulties of using the finite element method, with an ultimate aim of developing a general analytical method for the study of reinforced concrete members in the full range of loading.

LATERAL INSTABILITY OF REINFORCED CONCRETE BEAMS UNDER UNIFORM BENDING MOMENTS. 64-15

Campbell Massey—Mar. 1967, pp. 164–172

The lateral stability conditions for a single span slender reinforced concrete beam under uniform bending moment are examined. A method for predicting the critical bending moment is suggested, based on the lateral bending and torsional rigidities and, in the case of doubly reinforced beams, on the warping rigidity. It is shown that these rigidities depend not only on the over-all dimensions of the cross section but also on the percentage of steel, the number, type and size of stirrups, and the state of stress. Experimental results are described which support the proposed theory. These results are then compared with standard design recommendations.

RECOMMENDED PRACTICE FOR MANUFACTURED REINFORCED CONCRETE FLOOR AND ROOF UNITS (ACI 512-67). 64-16

Announcement of ACI standard

Separate copies of the standard available

ACI 512-67 supersedes ACI 711-58 and Title No. 63-30

ACI-ASCE Committee 512—Apr. 1967, p. 185

Recommendations are made for the design, manufacture, and erection of precast reinforced concrete floor and roof units having spans of 35 ft (11 m) or less. Unit stress, ultimate strength, and a test method of strength design are recommended. Recommendations are made regarding bearing lengths, bar spacings, minimum reinforcement, and holes. Quality requirements and acceptance procedures are discussed. Prestressed concrete members are not covered in the report.

STRUCTURAL PLAIN CONCRETE 64-17

ACI Committee 322—Apr. 1967, pp. 186–189

Structural plain concrete is defined as concrete used for structural elements and having no reinforcement or an amount of reinforcement less than specified in ACI 318-63. The required quality of concrete and allowable stresses, both for working stress design and ultimate strength design, are presented. The report confines itself to concrete resting on ground or supported by other structural elements and presents specific recommendations for walls and pedestals and footings.

CORE AND CYLINDER STRENGTHS OF NATURAL AND LIGHTWEIGHT CONCRETE 64-18

Richard H. Campbell and Robert E. Tobin—Apr. 1967, pp. 190–195

The compressive strength of laboratory cured and field cured cylinders are compared with 4 and 6 in. diameter cores at ages up to 84 days. Nearly 500 samples of natural and lightweight concrete under simulated job conditions showed that all cores at comparable ages tested lower than cylinders.

COLUMNS UNDER FLEXURE-WORKING STRESS DESIGN 64-19

Arieh Lev Abolitz—Apr. 1967, pp. 196–201

Approximate equations for the working stress design of common column sections subject to flexure, both for tension and compression control, are presented for use by designers who prefer formulas to charts and tables. These equations may be used in design like the corresponding semiempirical formulas given in the ACI Code for ultimate strength design. They are about as accurate as the familiar flexural formula.

STRENGTHS OF PREPACKED CONCRETE AND REINFORCED PREPACKED CONCRETE BEAMS 64-20

Yuzo Akatsuka and Hiraku Moriguchi—Apr. 1967, pp. 204–212

Strength tests were carried out on prepacked concrete and reinforced prepacked concrete beams and the results were compared with those obtained on normal concrete. Little difference was found in strength properties between prepacked and normal concretes. It was also found that the predicted flexural strengths of reinforced prepacked concrete based on either the straight-line theory or the ultimate strength theory were greater than those of normal concrete. Consequently, it is concluded that for practical purposes of designing reinforced flexural members the accepted formulas based on either the straight-line theory or the ultimate strength theory may be applied to prepacked concrete as well as to conventional normal concrete.

THE AMERICAN CONCRETE INSTITUTE—PAST—PRESENT—FUTURE 64-21

Arthur R. Anderson—May 1967, pp. 229–233

Retiring ACI President Arthur R. Anderson—Vice-President, ABAM Engineers, Inc., and Vice-President, Concrete Technology Corp., both of Tacoma, Wash.—summarizes ACI's past accomplishments, present activities, and future goals.

NEW DEVELOPMENTS IN DETAILING PRACTICE 64-22

ACI COMMITTEE 315—May 1967, pp. 234–239

ACI Committee 315 is charged with the mission of maintaining and keeping current the ACI Detailing Manual. Since the adoption of the current Manual in 1965, the rapid growth in usage of high strength reinforcing bars and ultimate strength design makes necessary certain modifications of practice in column tie details and standard hooks. Pending proposal of a complete revision to the Manual, the results of the committee studies in these areas are presented as interim recommendations for good practice. Discussion of these interim recommendations is particularly invited to provide a complete record of experiences in their use.

IMPULSE METHODS FOR CONTROLLING THE CONSTRUCTION SPEED OF PRESTRESSED CONCRETE BRIDGES 64-23

Tibor Javor—May 1967, pp. 240–243

Describes the application of two nondestructive impulse methods, viz., the ultrasonic and the sonic hammer methods for checking the quality of concrete. Compares the two methods and gives their advantages and disadvantages especially in relation to speeding up the construction of prestressed concrete bridges.

FATIGUE TESTS OF REINFORCING BARS—TACK WELDING OF STIRRUPS 64-24

Kenneth T. Burton and Eivind Hognestad—May 1967, pp. 244–252

This paper reports fatigue tests of concrete beams with tied stirrups and with stirrups tack welded to the main tension reinforcement. The beams were reinforced with #8 intermediate grade and ASTM A 432 high strength bars of one deformation pattern. Test results of 68 beams indicate that careless tack welding of stirrups can reduce fatigue life of the longitudinal bars at a given stress range by 75 percent. Similarly, stress range at 5 million cycles can be reduced by 35 percent. Bar yield strength had only minor influence on fatigue strength for comparable stress ranges at 5 million repetitions.

FIELD EXPOSURE TESTS OF REINFORCED CONCRETE BEAMS 64-25

Edwin C. Roshore—May 1967, pp. 253–257

Two series of reinforced concrete beams were made and exposed to severe natural weathering at Treat Island, Maine.

Variables under study were type of concrete, thickness of concrete cover over steel and tensile stress in the reinforcing steel, position of the steel, and type of steel used.

Results after 15 winters of exposure of the first series of beams (Series A) indicated that the air-entrained beams were significantly more resistant to the weathering than the non-air-entrained beams, and that the beams with reinforcing steel having deformations conforming to ASTM Standard A 305 were more resistant to the weathering than those with reinforcing steel having old-style deformations. These tests formed the basis for a change in Corps of Engineers practice in 1958 by which allowable steel stresses were increased from 18,000 to 20,000 psi (1260 to 1400 kg per sq cm). This change has resulted in a saving of cost in Corps of Engineers construction averaging $1.25 million per year since the change was made.

Results after 12 winters of exposure of the second series of beams (Series B) indicated that more exposure is needed to produce deterioration sufficient to permit unambiguous conclusions.

Exposure of both series of beams is continuing.

ELASTIC-PLASTIC ANALYSIS OF ARCHES 64-26

Bernard Grossfield and James Michalos—May 1967, pp. 259–265

A method is presented for determining the behavior, to failure, of a reinforced concrete arch. The response of the

structure is obtained by superimposing nonlinear elastic analyses for successive, small increments of loading. The properties of each cross section of the arch, including the position of the bending axis, are reevaluated for every increment of loading, using a trial and error technique. A large digital computer was used to obtain numerical results.

A YIELD CRITERION FOR REINFORCED CONCRETE SLABS 64-27

Rolf Lenschow and Mete A. Sozen—May 1967, pp. 266–273

A general yield criterion for reinforced concrete plane elements subjected to combination of flexural and torsional moments is developed. The proposed criterion is compared with the results of special experiments devised to test it.

AUTOMATION ON THE JOB SITE 64-28

Charles J. Pankow—June 1967, pp. 281–287

Describes how preplanning between architect, engineer, and builder can provide more economical and efficient construction. The construction of one project where this approach was used is described.

CREEP TESTS OF TWO-WAY PRESTRESSED CONCRETE 64-29

Howard L. Furr—June 1967, pp. 288–294

Creep tests on small prestressed structural lightweight concrete slabs are discussed. Three 2 × 2 ft × 2 ½ in. slabs prestressed equally in two directions to 1000, 2000, and 3000 psi, respectively, were gaged for strain. One slab of similar dimensions was prestressed to 2000 psi on one direction. Small 3 × 3 × 16-in. prisms were spring loaded axially to the same initial stresses as the prestressed slabs.

It was found that creep in the 2000 psi two-way slab was virtually the same as that in the 2000 psi one-way slab. Prestress losses after 313 days were about 25 and 30 percent in the 2000 and 3000 psi slabs, respectively.

SIMPLIFIED ERECTION METHOD FOR SHELL STRUCTURES 64-30

Sylwester Oleszkiewicz and Zbigniew Parzniewski—June 1967, pp. 295–300

Presents a method of constructing shell structures with the elimination of traditional formwork. Several scaled models were made, including a full-scale dome-shaped shell. The experiments indicate that this construction technique may save over 20 percent of both labor and material costs, with only a slight increase in the amount of steel.

NUMERICAL CREEP ANALYSES APPLIED TO CONCRETE STRUCTURES 64-31

George L. England—June 1967, pp. 301–311

The effects of creep and temperature on the behavior of concrete structures are discussed. Then based on a specific thermal creep concept, three methods of analyses are described: (1) rate of creep, (2) relaxation, and (3) strain hardening. These analyses are described in relation to step-by-step methods of solution and are shown to be capable of estimating the time-dependent behavior of concrete structures subject to certain conditions of temperature and loading. It is concluded that some saving of computational time can result from simultaneous solution, to a given problem, by the first two types of analyses.

DESIGN OF COMBINED FOOTINGS USING SUPPORT REACTION AND MOMENT INFLUENCE LINES OF CONTINUOUS BEAM ON ELASTIC SUPPORTS 64-32

Leslie J. Szava-Kovats—June 1967, pp. 312–319

Presents a method for designing combined footings based on a mathematical model (substitute structure), the solution of which is facilitated by influence coefficients. The accuracy of the method in the use of the substitute structure depends on the relative rigidity of the system. However, the inclusion of a margin of error diagram and tables makes the proposed design method useful to practicing engineers.

PROPOSED REVISION OF ACI 347-63: RECOMMENDED PRACTICE FOR CONCRETE FORMWORK 64-33

ACI Committee 347—July 1967, pp. 337–373

Presents brief introductory statement on the need for formwork standards based on the fact that 35 to 60 percent of the total cost of the concrete work in a project in the United States is the formwork. A section is given on engineer-architect specifications noting the kind and amount of specification the engineer or architect should provide the contractor. Since the committee concludes that formwork design and engineering, as well as construction, must be the responsibility of the contractor, the recommendations contained in the report are directed to that group. However, an understanding of these recommendations by engineers and architects will aid these groups in their specification functions.

The report is divided into five chapters: 1. Design, 2. Construction, 3. Materials for Formwork, 4. Forms for Special Structures, and 5. Formwork for Special Methods of Construction.

HYPAR ROOF OF THE MADONNA DI POMPEI CHURCH, MONTREAL, CANADA 64-34

Felix M. Kraus—July 1967, pp. 374–383

Describes the design and construction of the hyperbolic paraboloid roof for the Madonna di Pompei Church in Montreal, Canada. This hypar roof is an anticlastic shell supported on two boundaries and free along the remaining two boundaries, which are unified into one hyperbola. Calculations show pronounced cantilever and arch action of the shell. Field deflection measurements indicate substantial shell stiffness as well as interaction of the unequal shell quadrants.

SAND REPLACEMENT IN STRUCTURAL LIGHTWEIGHT CONCRETE-SPLITTING TENSILE STRENGTH 64-35

Donald W. Pfeifer—July 1967, pp. 384–392

The splitting tensile strengths of seven structural lightweight concretes containing natural sand fines are reported. This paper is third in a series regarding the partial or complete replacement of lightweight fines with sand.

The test results show equal splitting strengths for all continuously moist cured lightweight and normal weight concretes when the compressive strengths were equal. However, the splitting strengths of the lightweight concretes were generally reduced when the cylinders were allowed to dry before testing. The use of sand fines minimized this strength reduction.

CONSTRUCTION OF PRESTRESSED PAVEMENT AT AN AIRPORT IN PORTUGAL 64-36

Goswin Mittelmann—July 1967, pp. 393–397

Describes the construction of a prestressed concrete runway and taxiway for an airport in Portugal. The pavement was pretensioned longitudinally and post-tensioned transversely. The runway is about 4000 m (13,100 ft) long and 60 m (197 ft) wide while the taxiway is approximately 3200 m (10,500 ft) long and 30 m (98 ft) wide. Each month about 270 tons (300 U.S. tons) of prestressing steel was installed and nearly 5500 cu m (7200 cu yd) of concrete was placed. The project was completed in 38 weeks.

DETERMINATION OF STRAIN DISTRIBUTION AND CURVATURE IN A REINFORCED CONCRETE SECTION SUBJECTED TO BENDING MOMENT AND LONGITUDINAL LOAD 64-37

German Gurfinkel and Arthur Robinson—July 1967, pp. 398–403

In many problems associated with refined analysis and interpretation of experiments on reinforced concrete beam-columns, it is necessary to determine the strain distribution in any section of the member from the bending moment and longitudinal force acting at that section. In the analysis which is presented in this paper, the strains are assumed to be linearly distributed in the cross section. Realistic stress-strain relations are used for both concrete and steel. A numerical scheme, the extended Newton-Raphson procedure, is applied to solve the problem in the general case. A numerical example is given to illustrate the method.

STRUCTURAL BEHAVIOR OF CONCRETE FILLED STEEL TUBES 64-38

Noel J. Gardner and E. Ronald Jacobson—July 1967, pp. 404–413

Describes a theoretical and experimental investigation into the behavior of concrete filled steel tubes as axially loaded compression members. The experimental results are also compared to the loads allowed by the NBC and ACI and recommendations made.

GUIDE FOR STRUCTURAL LIGHTWEIGHT AGGREGATE CONCRETE 64-39

ACI Committee 213—Aug. 1967, pp. 433–469

This guide summarizes the present state of the technology. It presents and interprets the data on lightweight aggregate concretes from many laboratory and field sources. These include the comprehensive studies at the University of Illinois in 1931, the parallel investigations by the U.S. Bureau of Reclamation and the National Bureau of Standards in 1949, numerous recent laboratory studies, accumulated experience resulting from greatly increased and successful use, and performance of structural lightweight aggregate concrete in service.

The guide is intended for the architect, engineer, contractor, concrete producer, and student. It includes a definition of lightweight aggregate concrete for structural purposes; it discusses in condensed fashion the production methods and inherent properties of lightweight aggregates for structural concrete. This is followed by current practices on proportioning, mixing, transporting, placing; properties of hardened concrete; and finally, the design of structural concrete, with special reference to the 1963 ACI Building Code.

DESIGN OF CONCRETE OVERLAYS FOR PAVEMENTS 64-40

Subcommittee VIII, ACi Committee 325—Aug. 1967, pp. 470–474

This report up-dates the 1958 report and presents further information on bonded concrete resurfacing. Consideration is also given to concrete overlays on flexible pavements. Design procedures which will give dependable results in situations evaluated by mature engineering judgment are presented; however, note is made that they are subject to further refinement.

DESIGN AND CONSTRUCTION OF NORTH TERMINAL BUILDING AT DETROIT METROPOLITAN AIRPORT 64-41

DESIGN OF GIANT POST-TENSIONED GIRDERS

Lin Y. Huang, N. P. Angeles, Howard R. May, and Keith C. Thornton

CONSTRUCTION OF POST-TENSIONED ROOF PANELS

Jack L. Korb

Aug. 1967, pp. 475–491

A two-paper report combined under one general title, the following two papers describe first the design presented by members of the design team, then construction presented by a member of the construction firm that built this imposing structure.

A key feature of the $5,500,000 North Terminal Building of the Detroit Metropolitan Airport is the horizontally curved post-tensioned girders supporting the roof. The 150 × 300-ft roof consists of five independent 70 × 232-ft post-tensioned panels separated by 5 ft wide continuous skylight strips. Each panel is made up of a slab, upturned perimeter beams, two horizontally curved girders, and two cross-arm beams. A single pair of tapering 60 ft reinforced concrete columns support each roof panel. The columns vary in cross section from a four-pointed star at the base to a hexagon at the top. A combination of board finishing for the columns, roof slab and beams, and sandblasting for the wall panels gives the terminal building a pleasing architectural appearance.

The choice of construction method, engineering assumptions, and structural design are described by the structural engineers, while the construction of the roof panels and columns, formwork and erection, post-tensioning procedures, and field control are discussed by the vice president of the general contractor's firm.

WORKING STRESS COLUMN DESIGN USING INTERACTION DIAGRAMS 64-42

George A. Mylonas—Aug. 1967, pp. 492–498

A simplified method for working stress column design is given, by using the interaction diagrams in the *Reinforced Concrete Design Handbook*, for solving the case of biaxial bending.

RATIONALIZATION OF THE TRIAL MIX APPROACH TO CONCRETE MIX PROPORTIONING AND CONCRETE CONTROL THEREFROM 64-43

Raymond J. Frost—Aug. 1967, pp. 499–509

An integral part of concrete mix proportioning is the preparation of trial mixes. The success of and adjustments to such trials are largely a matter of judgment which has not been analyzed quantitatively in the existing methods.

This paper reviews such proportioning methods and presents the data in a form whereby any desired end result can be extrapolated after one trial mix (successful or not).

The method uses the factors of fineness modulus (of both aggregates and total mix) and water content (as percentage of the total ingredients) as the factors influencing the end result. Charts and formulas are presented which show the manner in which these variables may be influenced.

GUIDE FOR CAST-IN-PLACE LOW DENSITY CONCRETE 64-44

ACI Committee 523—Sept. 1967, pp. 529–535

This Guide provides information on materials, properties, design, and proper handling of cast-in-place concretes having oven-dry unit weights of 50 pcf (800 kg/m^3) or less. Such concretes achieve their low weight by the use of low density mineral aggregates or foam. These concretes are used to the greatest extent in roof deck systems, where advantage is usually taken of their insulating value.

INCREASE IN CRACK WIDTH IN REINFORCED CONCRETE BEAMS UNDER SUSTAINED LOADING 64-45

LeRoy A. Lutz, Nand K. Sharma, and Peter Gergely —Sept. 1967, pp. 538–546

Test results are presented for the increase of flexural crack widths due to sustained loading. The width of the cracks were measured for 5 months. The effects of compression reinforcement were also investigated. The widening of the cracks is explained by the increase in steel stress at sections between surface cracks due to increased internal cracking, and by the creep of concrete.

DEVELOPMENT OF PRECAST, REINFORCED, AND PRESTRESSED CONCRETE ELEMENTS FOR INDUSTRIAL SINGLE-STORY BUILDINGS IN ROMANIA 64-46

Mahai Popovici—Sept. 1967, pp. 547–557

Traces the evolution of the precast concrete industry in Romania for single-story buildings. Describes the basic concept of the standard design and the construction techniques that made possible the mass production of precast elements. The structural design was based on static and dynamic (including seismic effects) considerations.

DYNAMIC DESIGN OF REINFORCED CONCRETE CHIMNEYS 64-47

Lawrence C. Maugh and Wadi S. Rumman—Sept. 1967, pp. 558–567

Discusses the design of reinforced concrete chimneys for both earthquake and wind resonant forces. The earthquake response is treated by solving the fundamental equation of motion with the forcing function being that of an accelerogram of an actual earthquake. Several accelerograms of strong motion earthquakes are used and a certain fraction of the average response is used in the design. In case of wind vibration, a sinusoidal forcing function is used which has the same frequency as that of the chimney.

The paper emphasizes the importance of designing reinforced concrete chimneys for a maximum stress condition. This design procedure is necessary because of a rapid increase in steel stresses due to a relatively small increase in the bending moment. The rate of increase of the steel stresses also depends on the percentage of steel used; the higher the percentage the lower will be the rate of increase.

FLAT PLATE ANALYSIS OF OLENTANGY RIVER DORMITORIES 64-48

Russell S. Fling—Sept. 1967, pp. 568–574

Describes the design of flat plate floor slabs for two 24-story dormitories by model analysis using a scale acrylic plastic model of a typical slab with supporting columns and walls, loaded with negative air pressure. Biaxial strains were measured and converted to stresses using the measured value for the modulus of elasticity and Poisson's ratio. Distribution of the stresses was analyzed and stresses at critical sections were converted to moments from which the required reinforcement was determined.

Discusses some details of reinforcing and thermal movement of 20-story high concrete walls.

A NEW CONCEPT OF STORAGE BIN CONSTRUCTION 64-49

John M. Haeger and Sargis S. Safarian—Sept. 1967, pp. 575–579

Describes the construction of a group of four precast and vertically post-tensioned bins, 16 ft in diameter, of the Ideal Cement Company terminal at Port of Palm Beach, Florida. Speed and simplicity of construction were experienced.

EFFECT OF STRAIN GRADIENT ON THE STRESS-STRAIN CURVE OF MORTAR AND CONCRETE 64-50

Llewellyn E. Clark, Kurt H. Gerstle, and Leonard G. Tulin—Sept. 1967, pp. 580–586

Recent investigations have indicated that the microcracking of concrete and the associated stress-strain curve depend on the strain gradient. It is also recognized that the time rate of straining affects the stress-strain curve. The relative significance of these two effects, strain rate and strain gradient, has not previously been investigated. An experimental procedure was developed which provided for the individual control of bending and axial loads permitting maintenance of a constant strain gradient under uniform strain rates, making it possible to separate these two effects. Rectangular prisms of two different materials, mortar and concrete, were tested. The results indicate that the effect of a strain gradient on the stress-strain curves of mortar and concrete is minimal, except that the presence of a strain gradient tends to increase the maximum strain that can be reached before crushing occurs.

ANALYSIS OF COUPLED SHEAR WALLS 64-51

Alexander Coull and J. R. Choudhury—Sept. 1967, pp. 587–593

Curves are presented for the rapid evaluation of the stresses and maximum deflections in any system of coupled shear walls subjected to either a triangularly distributed lateral load or a point load at the top. The curves are derived from the continuous connection theory, in which the discrete system of connecting beams is replaced by an equivalent continuous medium.

PLASTER MORTAR FOR SMALL SCALE TESTS 64-52

B. V. Ranganatham, K. S. Subba Rao, and A. W. Hendry—Sept. 1967, pp. 594–601

To check the validity of theoretical analyses of structures, recourse is generally taken to extensive testing of small scale structures, taking care to see that the materials used in their construction faithfully reproduce the behavior of those used in the prototype. This investigation was devoted to the development of plaster mortar, which is shown to possess the mechanical properties warranted by similarity and also properties which make the construction of such test structures easy and rapid. Using plaster mortar in conjunction with threaded rods (which with or without suitable heat treatment simulate ordinary or cold-worked structural grade steel), ultimate moment capacity of simply supported beams was investigated and the specific bending resistance R obtained in terms of the reinforcement index q and the depth to shear span ratio (d/a). Test results of many earlier investigators of reinforced concrete beams have been collated and analyzed for R. Tests on simply supported 10½ in.

(26.7 cm) square plaster mortar slabs and 3 ft 6 in (1.1 m) square slabs were also conducted. The test results are discussed and the suitability of plaster mortar for small scale test structures brought out.

NOMENCLATURE FOR PHENOMENA OF FAILURE IN REINFORCED CONCRETE BEAMS 64-53

Ulf Bjuggren—Oct. 1967, pp. 625–632

The author makes a distinction between total failure and local failure of a reinforced concrete beam. Total failure always causes collapse of the beam, whereas local failure does not necessarily always give rise to collapse. Total failure occurs through rupture of the tensile reinforcement, through crushing of the concrete in the compressive zone, or through end anchorage failure. Local failure consists in the formation of cracks of various types and in a decrease in bond. The number of areas of local failure and their types influence the behavior of the beam, and determine the value of the load at total failure as well as the type of total failure. In some cases, the load at a local failure of a given type may be higher than the load at the corresponding total failure. In such cases, the collapse is usually brittle. To make possible a meaningful discussion of the problems in question, it is necessary to use a unified nomenclature to designate the different types of failure. The present article advances a tentative proposal for this nomenclature.

SHEAR CAPACITY OF LIGHTWEIGHT CONCRETE BEAMS. 64-54

Don L. Ivey and Eugene Buth—Oct. 1967, pp. 634–643

Twenty-six lightweight concrete beams were tested to provide additional information on the shear capacity of structural lightweight concrete and to evaluate the 1963 ACI Building Code requirements for shear. The beams tested in this program are compared with the present shear design formulas and with other design approaches that are being considered as modifications or changes to the 1963 ACI Code design procedure.

ANALYSIS OF INCLINED CRACKING SHEAR IN SLENDER REINFORCED CONCRETE BEAMS 64-55

James G. MacGregor and J. R. V. Walters—Oct. 1967, pp. 644–653

Describes an attempt to analytically define the shear capacity of slender concrete beams. The analysis assumes that failure is due to an inclined crack which develops in a region of combined shear and flexure. Flexural cracking, shear stress distribution, doweling forces and changes in the longitudinal steel stresses are considered. The analysis is used to study the effects of several variables on the shear capacity of slender reinforced concrete beams.

PROPOSED SYNTHESIS OF GAP-GRADED SHRINKAGE-COMPENSATING CONCRETE. 64-56

Shu-t'ien Li—Oct. 1967, pp. 654–661

A hypothesis is proposed for producing economical structural concrete of practically no shrinkage, at comparatively higher strength and modulus of elasticity, with lower creep, and with even much less cost than conventional concrete by the synthesis of gap-graded coarse aggregate and shrinkage-compensating matrix. Basically, it will constitute an unprecedented synthesis by taking the proven advantages of both gap-graded concrete and shrinkage-compensating expansive-cement concrete.

BEHAVIOR OF CONCRETE BEAMS REINFORCED WITH STEEL PLATES SUBJECTED TO DYNAMIC LOADS . . . 64-57

Ervin S. Perry, Ned H. Burns, and J. Neils Thompson —Oct. 1967, pp. 662–668

A total of 26 composite beams and 14 direct-shear specimens were loaded with dynamic and static loads to determine beam behavior and stud capacities. The main variables studied were stud diameter, concrete strength, effect of the type of loading, effect of number of studs per shear span and effect of using web reinforcement. Stud capacities determined from dynamic direct-shear tests compared very well with those determined from beam tests. The stud capacities varied directly with stud cross-sectional area and concrete strength.

DESIGN OF PARTIALLY PRESTRESSED CONCRETE BEAMS. 64-58

Paul W. Abeles—Oct. 1967, pp. 669–677

Discusses the design of "partially" prestressed concrete beams, covering also the two limiting cases, i.e., "fully" prestressed and ordinary reinforced concrete beams. The cross section is based on ultimate load conditions and the required effective prestressing force is related to an allowable nominal concrete tensile stress which for a definite reinforcing percentage ratio insures that under service load the widest crack does not exceed a permissible width. The type of steel required for the nontensioned reinforcement is governed by the permissible maximum deflection. Simple, well-known formulas are used.

ESTIMATE OF CONCRETE STRENGTH BY ULTRASONIC PULSE VELOCITY AND DAMPING CONSTANT 64-59

Andrej Galan—Oct. 1967, pp. 678–684

Shows by a regression analysis how the ultrasonic pulse velocity and ultrasonic pulse damping constant can be used to estimate the strength of concrete.

BENDING MOMENTS IN LONG WALLED TANKS. 64-60

J. D. Davies and Y. K. Cheung—Oct. 1967, pp. 685–690

Presents data relating to the bending moments developed in the walls of long tanks, particularly near the vertical corner joints between adjacent wall panels. A finite element solution has been used to calculate the vertical and horizontal bending moment coefficients for tank walls with the following boundary conditions along the top and bottom edges: (1) fixed base, free top; (2) fixed base, hinged top; and (3) hinged base, hinged top.

It is shown that the pattern of the bending moments in a long wall under hydrostatic loading is significantly modified near the ends and appropriate design values are included.

STRENGTH EVALUATION OF EXISTING CONCRETE BUILDINGS. 64-61

Subcommittee 1, ACI Committee 437—Nov. 1967, pp. 705–710

Strength of existing concrete buildings may be evaluated either analytically or by static load tests. These recommendations indicate when such an evaluation may be needed, establish criteria for selecting the evaluation method, and indicate the data and conditions necessary for conducting either type of evaluation. Methods of determining concrete and steel properties used in the analytical investigation are described. It is recommended that theoretical analysis follow

principles of ultimate strength design outlined in ACI 318-63, and that a structure be considered satisfactory if load factors and deflections satisfy requirements of ACI 318-63. Procedures for conducting static load tests are prescribed, and criteria are established for deflection and recovery of the structure being evaluated.

MECHANICS OF BOND AND SLIP OF DEFORMED BARS IN CONCRETE 64-62

LeRoy A. Lutz and Peter Gergely—Nov. 1967, pp. 711–721

The action of bonding forces, and the associated slip and cracking are examined for bars with various surface properties. The mechanics of slip of deformed bars in concrete is discussed, with the support of experimental data. The stresses and deformations in the concrete, caused by the bonding forces, are presented. The ACI Building Code shear stress requirements are studied in terms of the corresponding limiting bond stresses.

SHEAR STRENGTH OF LIGHTWEIGHT AGGREGATE REINFORCED CONCRETE FLAT PLATES 64-63

R. D. Mowrer and M. D. Vanderbilt—Nov. 1967, pp. 722–729

Test results of 51 reinforced concrete specimens assumed to represent the portion of a flat plate bounded by a line of contraflexure around an interior column are reported. Forty-three of the slabs were constructed using an expanded shale aggregate and eight contained normal weight sand and gravel aggregate. Nine of the lightweight slabs were loaded to failure with two or four edges clamped and the other slabs were tested with all edges simply supported. The analyses showed that none of the empirical shear strength equations in existence served consistently to predict the strengths of the current test specimens. A new type of test specimen which closely simulates the portion of an interior panel around a column is described. Tests of this type of specimen should lead to a more precise definition of the shear strength of flat plates.

DOOR OPENINGS IN SHEAR WALLS 64-64

Joseph Schwaighofer—Nov. 1967, pp. 730–734

Describes and discusses a model study of a 22 story high shear wall with three rows of openings. A comparison is made with Rosman's approximate theory.

SAND REPLACEMENT IN STRUCTURAL LIGHTWEIGHT CONCRETE—FREEZING AND THAWING TESTS 64-65

Donald W. Pfeifer—Nov. 1967, pp. 735–744

The freezing and thawing resistance of 47 structural lightweight concretes containing seven lightweight aggregates and varying amounts of natural sand fines are reported. This paper is fourth in a series regarding the partial or complete replacement of lightweight fines with sand. The seven lightweight aggregate concretes and companion sand and gravel aggregate concrete were evaluated at nominal compressive strengths of 3000 and 5000 psi.

The level of durability was generally raised when increasing amounts of sand fines were used in the 3000-psi concretes. All 5000-psi concretes were highly durable and the use of sand fines provided only minor improvements in this [illegible].

STRENGTH AND ENERGY ABSORPTION CAPABILITIES OF PLAIN CONCRETE UNDER DYNAMIC AND STATIC LOADINGS 64-66

Bill L. Atchley and Howard L. Furr—Nov. 1967, pp. 745–756

The energy absorption and strength carrying capacity of plain concrete subjected to both static and dynamic loading were investigated using sixty 6 × 12 in. cylinders. Three concretes with nominal strengths of 2500, 3700, and 5000 psi were tested with rates of stress ranging from 7.1 to 17 × 10^6 psi per sec. The lower and intermediate rates of loading were obtained through the use of the conventional hydraulic testing machine. In each test the specimen was supported in a load frame which had a floating head to insure proper load distribution.

The compressive strength and energy absorbed increased with the increase in the rate of loading, with evidence of becoming a constant value at the higher rates of loading. There were also increases in the secant modulus of elasticity and the strain as the rate of loading increased.

The internal strain, both static and dynamic, was larger than the external surface strain and also there was evidence that the concrete specimen behaved visco-elastically under dynamic loading.

T-BEAMS UNDER COMBINED BENDING, SHEAR, AND TORSION 64-67

Larry E. Farmer and Phil M. Ferguson—Nov. 1967, pp. 757–766

Test results of 26 semicontinuous reinforced concrete T-beams without web reinforcement under combined bending, shear, and torsion are reported. *M/Vd* ratios of 1.5, 3, and 6 were investigated, with the torsion segment 3*d*, 6*d*, and 12*d* long. All but four beams were over-reinforced to permit the primary study of shear and torsion interaction. The effect of torsional cross-sectional warping was investigated. Span length and cross-sectional warping were not found to influence the behavior greatly. Torsion lowered beam shear strength much less than ordinary plastic theory would suggest.

A GYPSUM MORTAR FOR SMALL-SCALE MODELS 64-68

Gajanan M. Sabnis and Richard N. White—Nov. 1967, pp. 767–774

A high strength gypsum in combination with sand has been investigated extensively as a potential material for simulating concrete in small scale models of concrete structures. Similitude requirements for a material to be used in model studies are discussed briefly. Tests for determining the appropriate physical properties of a number of mixes are described. It is shown that the behavior of model gypsum mortar is very close to that of the prototype concrete and that it has several advantages over model cement mortars. Size effects as related to compressive and tensile strength are studied; a surface sealing technique is used to reduce size effects to a low level. Charts are presented to facilitate proportioning of different strength mixes, and references are given to a number of successful applications of the gypsum mortar in model studies.

BEHAVIOR AND STRENGTH OF CONCRETE L-BEAMS UNDER COMBINED TORSION AND SHEAR 64-69

Ugur Ersoy and Phil M. Ferguson—Dec. 1967, pp. 793–801

Twenty-five small semicontinuous reinforced concrete L-beams without stirrups were tested under combined torsion, shear, and flexure. The test program was designed to study the effect of percentage of longitudinal steel, flange width and eccentricity of loading on both behavior and strength.

Ultimate strength was greatly influenced by the eccentricity. Even small torques decreased the capacity of test specimens; beams with smaller flanges suffered more reduction in capacity. The percentage of longitudinal steel influenced the ultimate load capacity of specimens tested under small eccentricities. At high eccentricities the effect of longitudinal steel was not significant.

EFFECT OF ELASTIC AND CREEP RECOVERIES OF CONCRETE ON LOSS OF PRESTRESS 64-70

Amin Ghali, Adam M. Neville, and P. C. Jha—Dec. 1967, pp. 802–810

An expression for the loss of prestress accounting for the elastic and creep recoveries induced by the relaxation of steel is developed. Experiments verifying this expression for beams with different tendon eccentricities, and stored at two relative humidities are described. The use of this expression leads to a more accurate estimate of the loss in prestress which aims at economy in design.

HORIZONTAL SHEAR CONNECTION IN COMPOSITE CONCRETE BEAMS UNDER REPEATED LOADS 64-71

John C. Badoux and C. L. Hulsbos—Dec. 1967, pp. 811–819

The research reported in this paper was an investigation of the strength of the joint between a precast concrete beam and a cast-in-place slab when the composite beam was subjected to repeated loading. The test program included 29 beams and the principal variables were the amount of joint reinforcement, the roughness of the joint, and the ratio of the shear span to the effective depth of the beam. Equations are presented which yield a conservative allowable stress for the horizontal shear in composite members under repeated loads.

TEST RESULTS ON THE LIMIT ANALYSIS OF A FIXED ENDED T-BEAM 64-72

Richard M. Barker and Kenneth H. Murray—Dec. 1967, pp. 820–826

Limit analysis of a reinforced concrete fixed ended T-beam is developed and discussed on comparison with experimental results. Moment-curvature relationships are presented from both experimental and theoretical data, and used in a numerical example of limit analysis.

TEST OF A POST-TENSIONED CONCRETE MASONRY WALL. 64-73

S. Rosenhaupt, F. D. Beresford, and F. A. Blakey—Dec. 1967, pp. 829–837

A test of a full sized post-tensioned concrete masonry wall is reported. The results of the test are compared with the design based on a truss analogy and with an analysis as a two-dimensional stress problem using McHenry's lattice analogy. Except in the neighborhood of a doorway in the wall, agreement between experimental results and both the truss and lattice analogy solutions was very good.

YIELD LINE ANALYSIS OF RECTANGULAR SLABS WITH CENTRAL OPENINGS . . . 64-74

Aron Zaslavsky—Dec. 1967, pp. 838–844

A yield line analysis is presented for simply supported rectangular concrete slabs (isotropically reinforced) with central rectangular openings, under uniformly distributed load. The three possible yield line patterns (mechanisms) are analyzed and design diagrams derived for rapid determination of the correct mechanism and the required ultimate moment. Numerical examples are provided.

V.65 SYNOPSES

Institute papers and reports of Proceedings V. 65 (January–December 1968 ACI JOURNAL)

PROPOSED REVISION OF ACI 613A-59: RECOMMENDED PRACTICE FOR SELECTING PROPORTIONS FOR STRUCTURAL LIGHTWEIGHT CONCRETE 65-1

ACI Committee 211—Jan. 1968, pp. 1–19

Describes, with examples, a method for proportioning and adjusting structural grade concrete containing lightweight aggregates. The method described uses a "specific gravity factor," determined by pycnometer test on the aggregates, which accounts for variations in moisture content of the aggregates. A tabular form is suggested for systematic calculation of batch weights and "effective displaced volumes." Examples are given for adjustments for change in aggregate moisture content, aggregate proportions, cement factor, slump, and air content.

ASSEMBLY HALL, UNIVERSITY OF HAVANA 65-2

German Gurfinkel—Jan. 1968, pp. 20–28

The assembly hall described herein was built among a set of multistory buildings and residence halls for the new campus of the University of Havana. An important feature of this project is the combination of construction methods used in its erection. Prefabrication, lift slab and conventional cast-in-place procedures were used to lower the cost of construction. The structure of the building was so designed that erection procedures and some of the design details necessary for a successful construction were used by the architects with great advantage. Close cooperation between designers resulted in an esthetic structure, the description of the design and construction of which are discussed in this paper.

REINFORCED CONCRETE T-BEAMS WITHOUT STIRRUPS UNDER COMBINED MOMENT AND TORSION 65-3

David J. Victor and Phil M. Ferguson—Jan. 1968, pp. 29–36

An investigation on the behavior of reinforced concrete T-beams without stirrups under combined moment and torsion in the absence of flexural shear is reported. From the results of this investigation and previous data from the literature, the interaction between torsion and moment is derived and shown to be dependent on the type of cross section.

STRENGTH AND BEHAVIOR OF TWO-SPAN CONTINUOUS PRETENSIONED CONCRETE BEAMS 65-4

M. A. Sheikh, H. A. Rawdon de Paiva, and Adam N. Neville—Jan. 1968, pp. 37–38

Tests on 11 beams were made to study the influence on strength and behavior of beams of: bond between tendon and concrete, distribution of longitudinal reinforcement, presence or absence of web reinforcement, and the moment-shear ratio. A difference in the role of the last factor in single span and continuous beams is discussed.

TORSION OF STRUCTURAL CONCRETE—INTERACTION SURFACE FOR COMBINED TORSION, SHEAR, AND BENDING IN BEAMS WITHOUT STIRRUPS 65-5

Thomas T. C. Hsu—Jan. 1968, pp. 51–60

Members subjected to combined torsion, shear, and bending can be conveniently studied by a nondimensional interaction surface. Using this method the tests available in the literature for reinforced concrete members without stirrups were analyzed, and a simple conservative design criterion is derived. An example design problem is presented.

CELLULAR FLAT PLATE CONSTRUCTION 65-6

Edgar H. Hendler—Feb. 1968, pp. 81–86

Describes a relatively new method of concrete flat plate construction using a cellular or hollow design. It is distinguished from ordinary waffle slab construction in that a continuous integral bottom sheet of structural concrete completely cellularizes the flat plate. The advantage of cellular construction in reducing dead weight combined with a use of deeper sections makes possible increased span lengths for the same live load as compared to conventional flat plate construction. Other inherent advantages of a cellular concrete system are also discussed.

ULTIMATE STRENGTH OF DEEP BEAMS IN SHEAR 65-7

V. Ramakrishnan and Y. Ananthanarayana—Feb. 1968, pp. 87–98

Describes an investigation of the behavior and ultimate shear strength of 26 single span simply supported reinforced concrete deep beams having different depth-span ratios. The beams were tested both under concentrated (at a single point and two points) and distributed loads. Based on the observed behavior and strength an equation is presented for predicting the ultimate shear strength of deep beams.

EFFECTS OF COLUMN EXPOSURE IN TALL STRUCTURES—DESIGN CONSIDERATIONS AND FIELD OBSERVATIONS OF BUILDINGS 65-8

Fazlur R. Khan and Mark Fintel—Feb. 1968, pp. 99–110

Discusses the philosophy for planning and design of buildings with exposed columns, based on performance and cost considerations. Two planning approaches are discussed: Designing for movement limitation and accommodation of the computed movement with appropriate details of partitions and frame. Application of the two philosophies is explained by showing examples of recent prominent structures. The result of a survey of 15 buildings with exposed columns ranging from 16 to 46 stories is presented. The observed behavior of partitions and frames is described. Temperature movement measurements of nine structures is also presented, and the measured movements compared with analytically predicted movement.

EFFECT OF CEMENT HYDRATION ON CONCRETE FORM PRESSURE 65-9

Elwood L. Ore and J. J. Straughan—Feb. 1968, pp. 111–120

The pressure of concrete on forms as affected by cement hydration and individual concrete ingredients at 70 F (21 C) was studied. The effect of cement hydration was investigated by comparing the behavior of concrete with and without a water-reducing, set-retarding agent to a nonhydrating mixture containing fly ash which had about the same plastic properties as concrete.

Oil filled pressure cells were adapted to measure pressure in a form 10 ft (3.05 m) high × 3 ft (0.91 m) wide × 1 ft (0.30 m) thick.

Results indicate that under these conditions, a workable concrete having a 3 to 4 in. (76 to 102 mm) slump does not behave as a fluid for any appreciable time without some outside energizing force such as vibration. The arching action of the aggregate is the earliest factor to limit the lateral pressure to 5 to 6 psi (0.35 to 0.42 kg/cm^2) equivalent to 5 to 6 ft (1.52 to 1.83 m) of head, with the method of placement and vibration used.

Hydration of the cement tended to limit form pressure under the normal vibration used but did not prevent an increase in pressure brought about by revibration until after 4 hr. The effect of set-retarding agent on cement hydration did not significantly alter the pressure.

A NEW APPROACH TO THE ULTIMATE STRENGTH OF CONCRETE IN PURE TORSION 65-10

V. Navaratnarajah—Feb. 1968, pp. 121–129

The failure of concrete beams in pure torsion is shown to be initiated by microcracking in the concrete. On this basis an ultimate strength approach is developed for circular and rectangular beams. The ultimate strength of rectangular plain concrete beams is based on the sand heap analogy of plastic torsion with stress levels varying from the stress at microcracking to the ultimate tensile strength of concrete. The strength of reinforced beams is shown to be the sum of the strength of plain concrete and the contribution of the reinforcement. The contribution of the reinforcement towards the ultimate strength is shown to be dependent on the actual stress levels in them at failure.

SAND REPLACEMENT IN STRUCTURAL LIGHTWEIGHT CONCRETE—CREEP AND SHRINKAGE STUDIES 65-11

Donald W. Pfeifer—Feb. 1968, pp. 131–140

The creep and shrinkage volume changes of 47 structural lightweight concretes containing seven lightweight aggregates and varying amounts of a natural sand are reported. This paper is fifth and final in a series regarding the partial or complete replacement of lightweight fines with sand.

Creep and shrinkage were generally reduced when increasing amounts of sand fines were used. Data are presented which correlate the reduced volume changes to increasing volume of coarse aggregate in the concrete. The increase of coarse aggregate volume arises from the proportioning procedures, and also reflects the reduction of water, cement, and fine aggregates in lightweight concretes containing increasing amounts of natural sand.

ESTIMATING PROPORTIONS FOR STRUCTURAL CONCRETE MIXTURES 65-12

Sandor Popovics—Feb. 1968, pp. 143–150

Simple formulas are presented for the prediction of fresh unit weight as well as for the relationship between cement content and mix proportions of various structural concretes. These formulas are useful mainly for proportioning structural lightweight and heavyweight concretes because the unit weight and the cement content have greater significance for these mixtures than for normal weight concretes. The formulas are also applicable when the mineral aggregate in question is blended with aggregates of differing specific gravities—such as a conventional sand and a lightweight coarse aggregate—provided that the average specific gravity of the blended aggregate is computed by a formula developed for this purpose. Experimental results support the formulas within a wide range. The limits of validity are given. Numerical examples illustrate the use of the formulas.

STRUCTURAL DESIGN OF THE HUMANITIES AND SOCIAL SCIENCES BUILDING AT YORK UNIVERSITY 65-13

Demetri Zavitzianos—Mar. 1968, pp. 169–175

Presents a structural description of the nine story, 560 ft long Humanities and Social Sciences Building now under construction at York University, Toronto. The building consists of two main blocks connected by a corridor link structure. It is constructed of rigid concrete frames supporting concrete joists and braced laterally by interior shear walls. Both the extreme length of the building and various architectural requirements such as interrupted columns created serious structural complications. These are discussed in addition to shrinkage and temperature effects which resulted in severe reinforcement requirements.

CONCRETE STRENGTH IN STRUCTURES 65-14

Delmar L. Bloem—Mar. 1968, pp. 176–187

The significance of concrete compressive strength measurement by various methods was investigated. Pairs of slabs from three concretes were subjected to good and poor curing. Cores and push-out cylinders were removed at six ages up to 1 year and tested for strength. Corresponding tests of molded cylinders brought the total specimens to 216 cores, 216 push-out cylinders, and 270 molded cylinders.

The data indicate that two concepts of strength should be distinguished: (1) strength as a measure of load-carrying capacity in structures, and (2) strength as a measure of concrete quality and uniformity. The relation of the latter (determined by standard cylinder tests) to the former (determined on cores from the structure) is extremely variable.

A DIRECT COMPUTER SOLUTION FOR SLABS ON FOUNDATION 65-15

W. Ronald Hudson and C. Fred Stelzer, Jr.—Mar. 1968, pp. 188–201

A direct method of solving for deflected shapes of freely discontinuous pavement slabs subjected to a variety of loads including transverse loads in plane forces and externally applied couples is presented. The method applies to slabs with freely variable foundation support including holes in the subgrade and rapidly solves finite element slab equations developed, unhindered by closure parameters necessary in iterative techniques of solution. A computer program uses equations and techniques developed. Sample problems illustrate generality of the method and convenience to the user. Results compare well with closed-form solutions and with previous solutions developed by other techniques.

EFFECT OF DEGREE OF SATURATION ON THE FROST RESISTANCE OF MORTAR MIXES 65-16

Cameron MacInnis and James J. Beaudoin—Mar. 1968, pp. 203–208

A one-cycle freezing test, involving length measurements during freezing, is used in an attempt to establish limiting maximum water-cement ratios for concretes for different exposure conditions. Mortar prisms were cast from a series of mixes, (both air-entrained and non-air-entrained) covering a range of water-cement ratios from 0.40 to 0.70. After being moist cured for 1 month the prisms were then conditioned to various degrees of saturation (to simulate different exposure conditions) and subjected to the freezing test. Frost susceptibility of the various mixes was determined from the length change patterns produced in the freezing test. Critical degree of saturation was found to be approximately 90 percent. Air entrainment was found to provide protection up to a water-cement ratio of 0.58.

ULTIMATE STRENGTH OF REINFORCED CONCRETE BEAMS IN COMBINED TORSION AND SHEAR 65-17

John P. Klus—Mar. 1968, pp. 210–216

Classical theory shows that both torsion and flexural shear have the same point of maximum stress for rectangular sections. However, the stress distribution throughout the test of the cross section varies significantly. A series of rectangular reinforced concrete beams with normal percentages of both longitudinal and transverse steel was tested and the interaction of their torsional and flexural shear capacities was developed. The effects of bending and amount of reinforcement are discussed. Various interaction formulas are compared.

COMPONENTS OF CREEP IN MATURE CONCRETE 65-18

J. M. Illston—Mar. 1968, pp. 219–227

Tests are reported on the creep and recovery of concrete under uniaxial compression and tension, applied at advanced ages of over a year. The characteristics of the creep components (irrecoverable or flow, recoverable or delayed elastic) for young and mature concrete are compared, and found to be in reasonable agreement. The rate of flow method (based on the two components) for calculating strain under variable stress is discussed. In particular, it is compared favorably with super-position.

PROPOSED DESIGN FOR EXPERIMENTAL PRESTRESSED PAVEMENT SLAB 65-19

Subcommittee VI, ACI Committee 325—Apr. 1968, pp. 249–265

This report considers factors pertinent to the prestressing concept, reviews results of a number of experimental projects, and presents design details for experimental sections of prestressed pavement which can be built following existing highway construction practices in North America, and using commercially available prestressing equipment.

Data are presented for slabs from 400 to 900 ft (120 to 270 m) long, 24 ft (7.3 m) wide, and 5 in. (13 cm) thick, with post-tensioned tendons spaced 24 in. (61 cm) on centers to provide at least 100 psi (7 kgf/cm^2) effective prestress at midlength of the slab. Details are suggested for 600-ft (180-m) slabs.

Post-tensioning is recommended to simplify operations using developed techniques, and to avoid the cost of pavement anchor blocks. The suggested design is supported by data from recent research on the performance of thin slabs under highway traffic. Length changes anticipated are predicted on the basis of trends in earlier experiments. The design for slab ends is intended to conservatively reinforce these critical locations, assure even joints, protect the foundation, and aid drainage rather than to meet minimum design needs with the most economical construction.

A PROGRAM TO TEST CEMENTS FOR VARIATIONS IN STRENGTH PRODUCING PROPERTIES 65-20

Richard H. Campbell—Apr. 1968, pp. 266–275

Five brands of cement produced in Southern California were sampled and tested monthly by a ready mixed concrete producer. The compressive strength potential of the cements was checked by using a cube test which used a more realistic cement content and a constant water content of 65 percent. The results of 410 sets of cubes, chemical analysis, and fineness determinations are reported for a 5 year period.

A sample of a blended control cement was included each month to check the workmanship of the laboratory conducting the tests. An analysis of the variations in reported strength of the controls revealed a pattern. It was felt that this pattern was caused by environmental influences of the laboratory and contributed to a portion of the variations in the cements being tested.

COVERED BRIDGE HANGS FROM ITS ROOF 65-21

Horst Berger—Apr. 1968, pp. 276–281

Covered footbridge consists of two identical symmetrical double cantilevers built one after the other. Structure is 8 in. (20 cm) thick folded slab system made up of roof slab and triangular side walls with post-tensioning tendons in the roof slab. Walkway panels are precast and suspended from superstructure.

PLASTIC SHRINKAGE CRACKING 65-22

Dan Ravina and Rahel Shalon—Apr. 1968, 282–292

Plastic shrinkage cracking of mortars exposed to different conditions, as prevalent in hot-dry climates, was investigated under controlled conditions. The variables studied were air temperature and humidity, wind velocity, mortar temperature, type and content of cement, and consistency. Shrinkage, tensile strength and tensile stress of fresh mortars, evaporation and time of cracking were measured. Width, depth, and length measurements of the cracks were also taken.

The results confirm that rapid evaporation has a predominant effect on plastic shrinkage cracking. Other conclusions are that plastic shrinkage cracking is not a direct function of water loss, evaporation rate or shrinkage, and that semiplastic mortar did not crack under high evaporation conditions which brought about severe cracking of plastic and wet mortars. It was also established that the first crack coincides with the transition from the intensive, practically unrestrained, linear shrinkage of fresh mortar to the much slower rate due to restraint on stiffening of the mortar.

BEAMS UNDER DISTRIBUTED LOAD CREATING MOMENT, SHEAR, AND TORSION 65-23

David J. Victor and Phil M. Ferguson—Apr. 1968, pp. 295–308

Presents test data on 21 T-beams (without stirrups) subjected to eccentric distributed loading, and attempts to derive the interaction of moment, shear, and torsion. Based on the test results of this investigation and those available in the literature, modified design approaches are proposed.

A DOOR TO FIT THE KEY 65-24

Clyde E. Kesler—May 1968, pp. 353–356

Retiring ACI President Clyde E. Kesler—Professor of Theoretical and Applied Mechanics and of Civil Engineering,

University of Illinois, Urbana, Ill.—surveys ACI's current activities and outlines the steps it is taking to meet its future responsibilities.

NOTATION—THE CASE FOR A NEW SYSTEM 65-25

M. Daniel Vanderbilt—May 1968, pp. 357-361

Comments on the lack of system in notation as used in present concrete codes and related literature, and proposes guiding principles for a new, more orderly system of notation. The present form of notation for Chapters 16 and 26 of ACI 318–63 is compared with corresponding equivalent symbols in the proposed system.

STAGGERED TRANSVERSE WALL BEAMS FOR MULTISTORY CONCRETE BUILDINGS 65-26

Mark Fintel—May 1968, pp. 366–378

Discusses architectural, mechanical, structural, and economic aspects of a new framing system for reinforced concrete multistory residential buildings. Results of tests on two half-scale wall beam models are discussed. In addition to providing a structurally efficient system for resisting lateral loads, it was found that the staggered wall beam system possesses many architectural and planning advantages that will prove to be more economical in many situations. A comparative study of conventional schemes for three different heights of buildings shows the new system to be very competitive with other forms of construction.

EXPERIMENTAL RESEARCH IN ABUSE 65-27

A. T. Hersey—May 1968, pp. 379–383

Experimental research was done in a laboratory to duplicate field abuse of 4000 psi concrete on one job. It was desired to find the amount of strength loss due to high slump, extended mixing with slump kept at the high figure, high summer temperature, and partial abuse of cylinders. It is interesting that job strengths were almost duplicated using two different brands of cement.

OPTIMUM DESIGN OF CONCRETE SPREAD FOOTING BY COMPUTER 65-28

J. P. Kohli—May 1968, pp. 384–389

A computer program written for IBM/360 computer is described that does the optimum design of eccentrically loaded footing as per ACI Code 318-63. The footing may be restricted in dimensions in one or both directions.

The program designs a preliminary sized footing based on least area, calculates its cost in dollars, tries six different sizes close to the first size, compares the cost, and chooses the footing with the least cost. It also calculates the quantities of steel and concrete. Results obtained using the computer program are presented and used to show that the footing designed by computer is the optimum footing.

PRESSURE ON FORMS OF PREPACKED CONCRETE 65-29

Yuzo Akatsuka—May 1968, pp. 390–394

Observed data of pressure distribution on forms at an actual project are presented and discussed. A practical method of evaluating the pressure acting on prepacked concrete forms is suggested.

IMPROVED AIR-ENTRAINING ADMIXTURES FOR CONCRETE 65-30

Keith L. Johnson—May 1968, pp. 402–411

Test data covering improved, synthetically derived air-entraining admixtures for concrete are presented. The test data indicate that improved air-entraining admixtures can be formulated that overcome the loss in compressive strength usually associated with the incorporation of air into hydraulic cement mixes.

Data comparing the most promising of the materials tested with two established commercial products are presented and show that the valuable compressive strength properties are retained even in the presence of grossly excessive amounts of admixture such as might inadvertently be used in the field. It is expected that products based on this new material will be generally available to the concrete industry in the near future.

ALLOWABLE DEFLECTIONS 65-31

Subcommittee 1, ACI Committee 435—June 1968, pp. 433–444

Discusses the factors affecting the deflection of reinforced concrete members and emphasizes the importance of taking them all into consideration for an accurate estimate of deflection. Includes a table with an extensive list of situations requiring deflection limitations. These are based on L/Δ ratios and absolute values applied to the total or incremental deflections. Discusses the most significant parameters affecting the L/D ratios as an indirect limit on deflections. Presents formulas and graphs for L/D and gives examples for their use.

The report is divided into five chapters: Introduction, Computation of Deflections, Allowable Deflections, Allowable Span/Depth Ratios, and Correlation with Actual Building Structures.

MODAL DETERMINATION OF CONCRETE RESISTANCE TO POPOUT FORMATION 65-32

Hans Henrik Bache and Jens Christian Isen—June 1968, pp. 445–450

An experimental investigation was carried out to determine the resistance of popout formation in mortar. It was found that the required pressure to produce popouts on a concrete surface, from a spherically shaped particle near the surface, is directly proportional to the distance of the particle from the surface, and the tensile strength of the concrete, and inversely proportional to the size of the particle.

CREEP RECOVERY OF PLAIN CONCRETE 65-33

Donald R. Buettner and Ronald L. Hollrah—June 1968, pp. 452–461

Results of studies performed on one hundred, 1100 day old, plain concrete prisms are presented. These prisms had been placed under sustained load at 28 days. Creep recovery behavior, upon unloading, is examined. A number of prisms were unloaded and immediately reloaded to determine the effect of this load cycle on creep.

Elastic modulus and ultimate compressive strength tests were conducted to determine the effect of age and sustained load on these parameters.

SHORT AND LONG COLUMNS UNDER UNIAXIAL AND BIAXIAL FLEXURE 65-34

Arieh Lev Abolitz—June 1968, pp. 462–469

Equations for the working stress design of symmetrically reinforced short and long columns subject to flexure are presented. For rectangular columns, an alternative method slightly divergent from ACI 318-63, but possessing some advantages, is also given. For biaxial flexure weighted aver-

ages of some parameters are used, and all design equations are given in a form which applies to both uniaxial and biaxial flexure.

SIMPLIFIED DESCRIPTION OF CREEP SURFACE FOR A PORTLAND CEMENT MORTAR 65-35

Leonard G. Tulin—June 1968, pp. 470–476

The purpose of this study is the analysis of creep of plain portland cement mortar under uniform compressive stress from a phenomenological viewpoint with the objective of obtaining an alternate form of the strain-stress-time relationship to that obtained from visco-elastic analysis. The aim is to obtain relationships which are more usable than the expressions obtained from the analysis of rheological models. The techniques of dimensional analysis are used to organize an experimental program and to determine the form of the expression describing the strain-stress-time surface. A suitable least squares method is used in the numerical evaluation of parameters in the equation of the surface, and some conclusions are drawn regarding the validity of the results.

Comparison of the simplified equation of the creep surface with the results obtained from visco-elastic analyses shows that the alternate form for the surface is indeed simpler and therefore more usable than the results obtained from the analysis of rheological models. In this regard the objective of this investigation has been met.

RECOMMENDED PRACTICE FOR CONCRETE FORMWORK (ACI 347-68) 65-36

Announcement of ACI standard

Separate copies of the standard available

ACI 347-68 supersedes ACI 347-63 and Title No. 64-33

ACI Committee 347—July 1968, p. 497

Presents brief introductory statement on the need for formwork standards based on the fact that 35 to 60 percent of the total cost of the concrete work in a project in the United States is in the formwork. A section is given on engineer-architect specifications noting the kind and amount of specification the engineer or architect should provide the contractor. Since the committee concludes that formwork design and engineering, as well as construction, must be the responsibility of the contractor, the recommendations contained in the report are directed to that group. However, an understanding of these recommendations by engineers and architects will aid these groups in their specification functions.

The report is divided into five chapters: 1. Design, 2. Construction, 3. Materials for Formwork, 4. Forms for Special Structures, and 5. Formwork for Special Methods of Construction.

BIN WALL DESIGN AND CONSTRUCTION 65-37

ACI Committee 313—July 1968, pp. 499–506

This report presents wall design procedures for deep, cast-in-place, concrete bins and silos with a height equal to at least twice the diameter; free-standing or clustered; cylindrical, rectangular, or irregular in shape. These bins are intended to hold common granular solids such as cement, flour, sugar, grain, fertilizer, dry chemicals, coal, and similar materials. Allowable unit stresses, formulas for obtaining wall loads, design procedures, and determination of minimum wall thicknesses are given.

GUIDE FOR LOW DENSITY PRECAST CONCRETE FLOOR, ROOF, AND WALL UNITS 65-38

ACI Committee 523—July 1968, pp. 507–512

This Guide presents information on materials, fabrication, properties, design, and handling of precast concrete floor, roof, and wall slabs having oven-dry weights of 50 pcf (nom. 800 kg/m^3) or less. These concretes achieve their low weight by the use of low density mineral aggregates, air, or other gases.

ARCHITECTURAL CONCRETE 65–39

INTRODUCTION

James M. Shilstone—July 1968, pp. 514–515

A series of papers based on a symposium presented at the 1966 ACI Fall Meeting in New Orleans.

The series reviews the special thinking and considerations required for architectural concrete which must be structurally sound, aesthetically pleasing, and as economical as possible. The papers view the subject from the standpoint of architect, engineer, and builder.

Following a brief introduction, four authors cover, in turn, the architect's approach, structural implications, planning requirements, and construction.

ARCHITECT'S APPROACH TO ARCHITECTURAL CONCRETE 65-39a

Gyo Obata—July 1968, pp. 515–520

The choice of material is but one part of architectural design. When an architect selects concrete, he must first consider whether it is appropriate in structural terms. Then he must consider whether concrete is aesthetically right for the given project. The uses of concrete are varied and the results can be both structurally sound and beautiful to see. An architectural viewpoint is presented on the use of concrete as a structure and concrete as an aesthetic finish.

SOME STRUCTURAL IMPLICATIONS OF EXPOSED CONCRETE 65-39b

Matthys P. Levy—July 1968, pp. 520–525

When concrete is exposed architecturally, as well as being used structurally, the designer must consider a number of factors: structural aspects, properties and characteristics of the material, and construction methods. Apart from the obvious need to consider volumetric effects in design, such as shrinkage, creep, and volume change due to temperature, the very nature of the material requires special study. It is not sufficient to accept "average values" as design criteria, but testing on the actual concrete mix must be performed. Detailing and construction are important considerations for an architectural concrete structure, particularly the proper placement of joints, proper placement of reinforcement, and the method of curing.

ARCHITECTURAL CONCRETE: PLANNING REQUIREMENTS 65-39c

Larry C. Washburn—July 1968, pp. 515–531

Advances detailing planning is important in achieving economical effective architectural concrete. The designer must be mindful of the material with which he is working even during initial sketches. During design, the architect and engineer should consider such important construction elements as joints, form ties, shrinkage, etc. Lines which may appear effective on drawings can be difficult and costly to achieve in construction. Advance planning allows coordination of aesthetic, structural, and construction factors in the development of finishes and construction techniques which are appropriate to the particular design.

ARCHITECTURAL CONCRETE: CONTRACTOR'S EXECUTION 65-39d

E. Vernon Brown—July 1968, pp. 531–534

Architectural concrete requires advance planning and careful execution. The contractor should utilize a careful purchasing program, mock-ups, knowledgeable personnel, and specialists. Suppliers should be aware of quality standards for the job. Major items of consideration include: materials, forming techniques, concreting operations, and surface finishing.

EFFECTS OF CURING AND DRYING ENVIRONMENTS ON SPLITTING TENSILE STRENGTH OF CONCRETE 65-40

J. A. Hanson—July 1968, pp. 535–543

The splitting tensile strengths of lightweight and normal weight concretes were investigated in two test series which dealt with the effects of the curing and drying environments. The first series showed that the duration of the initial moist curing period prior to drying at 50 percent relative humidity had little effect on the splitting tensile strength. While there was a loss of splitting strength for the lightweight concrete early in the drying periods, continued storage in the drying atmosphere led to considerable gain in the splitting strengths. In the second series, concretes were subjected to drying for 21 days at different levels of relative humidity after initial moist curing for 7 days. Only minor changes of splitting strength were found as the relative humidity varied from 75 to 10 percent.

LARGE DIAMETER NONREINFORCED CAST-IN-PLACE CONCRETE PIPE 65-41

Ernest C. Fortier—July 1968, pp. 544–549

Describes continuously cast concrete pipe of 72, 84, and 96 in. in diameter. The machinery to produce the pipe is described as are tests and materials of cast-in-place pipe of these large dimensions.

PROPOSED ACI STANDARD RECOMMENDED PRACTICE FOR CONCRETE FLOOR AND SLAB CONSTRUCTION 65-42

ACI Committee 302—Aug. 1968, pp. 577–610

Quality of a concrete slab or floor is highly dependent on achieving a hard and durable surface which is plane and free of cracks. The properties that the surface has are determined by the quality of the concreting operations. Furthermore, timing of these concreting operations and finishing techniques is critical. Otherwise, undesirable changes occur at the wearing surface; these may lead to soft or dusting surfaces, permeable concrete, cracking, and poor durability.

This recommended practice tells how to produce good quality floors and slabs for various classes of service, emphasizing such aspects of construction as site preparation, concreting materials, concrete mixture proportions, concreting, workmanship, and curing. Adequate supervision and inspection are required of all job operations including particularly those of finishing.

GUIDE FOR DESIGN OF FOUNDATIONS AND SHOULDERS FOR CONCRETE PAVEMENTS 65-43

Subcommittee 1, ACI Committee 325—Aug. 1968, pp. 611–617

Methods are suggested for material selection, moisture control, and compaction or treatment of soils and materials to assure volume stability and uniform support for concrete pavements. Various environments are considered and appropriate methods of subgrade preparation outlined. Base and subbase functions are defined and adaptability of types of subbases discussed. Placement of materials to aid in subbase moisture control was emphasized in shoulder design.

References to pertinent technical manuals and articles are made throughout and AASHO and ASTM standard methods and tests are keyed where appropriate. A section on recognition of causes of deficiencies in existing pavements is included to alert the engineer to the consequences of improper construction or adverse environment.

MODEL TEST RESULTS OF VERTICAL AND HORIZONTAL LOADING OF INFILLED FRAMES 65-44

Bryan Stafford Smith—Aug. 1968, pp. 618–625

An investigation is described of the influence of vertical distributed loading on the horizontal stiffness and strength of masonry walls bounded by structural steel perimeter frames. It is found that for low vertical loads the horizontal stiffness and strength are greater than when there is no vertical loading. The modes of infill failure are as for horizontal loading only, i.e., a diagonal crack and corner compressive failure.

As the vertical load is increased, an optimum value is found for the maximum horizontal stiffness and strength beyond which the horizontal behavior deteriorates to the stage where the vertical load alone is sufficient to precipitate failure. The optimum vertical load is about half the vertical failure load, and it is accompanied by a transition from the horizontal load failure modes to vertical load failure modes.

Interaction curves are plotted to show the relation between the vertical loading and horizontal strength.

FACTORS IN THE ASEISMIC DESIGN OF REINFORCED CONCRETE SHEAR WALLS WITHOUT OPENINGS 65-45

Norman B. Green—Aug. 1968, pp. 629–633

Presents methods for calculating the ultimate strength of a shear wall and its deflection in the elastic and plastic or cracked condition based on tests of concrete beams.

Discusses the use of concrete shear walls for lateral bracing against seismic forces and the requirements for lateral load distribution to bracing elements. Presents a method for eliminating the effects of foundation yielding on lateral load distribution.

EXPLORATORY SHEAR TESTS EMPHASIZING PERCENTAGE OF LONGITUDINAL STEEL 65-46

K. S. Rajagopalan and Phil M. Ferguson—Aug. 1968, pp. 634–638

The shear strength of reinforced concrete beams as given by ACI 318-63 is known to be unconservative when the ratio of the longitudinal reinforcement, p, is small. The aim of the present investigation was to assess the extent of this inadequacy.

Ten rectangular beams without web reinforcement and having p between 0.0173 and 0.0025 were tested; results of 27 other beams with p less than 0.012 from various other investigators were also analyzed. All the beams considered had a/d ratios greater than 2.75.

Three rectangular beams with web reinforcement are also reported.

A symposium of seven brief papers based on a session sponsored by ACI Committee 311, Inspection of Concrete, at the 1967 ACI Fall Meeting in Des Moines.

The essentials of specification preparation are discussed. An engineer discusses the engineer's role in construction inspection, and a contractor presents the view that the major responsibility for inspection should be the contractor's. Some problems encountered in inspection are noted and a procedure to solve them offered. The advantages of quality control are looked at and the means by which inspection is actually being provided are reviewed. The final paper discusses ways in which private organizations can help train inspectors.

Long-time torsion tests on two specimens, one of plain concrete and the other of reinforced concrete, are presented together with short-time tests on two companion specimens. The effects of sustained loading on ultimate torsional strength and stiffness, the torque-twist curves, and the concrete strains are considered. The test results are also examined with regard to elastic and plastic theories.

Describes a comparative analytical study of the critical stress distributions developed in splitting tests on concrete specimens of various shapes. Assuming linear elastic behavior, the splitting stresses for the four following cases are investigated for concentrated line loading: (a) cylinder specimens; (b) cube specimens; (c) beam specimens; and (d) cube specimens tested diagonally.

It is demonstrated that Specimens (a), (b), and (c) have similar distribution patterns of tensile stress. In particular, the cube splitting test forms a suitable practical alternative to the standard cylinder splitting test to assess the tensile strength of concrete.

The study of Specimen (b) is extended to include the effects of distributed loads on the stress patterns.

This report gives material, construction, and design requirements for reinforced concrete chimneys. The report sets forth recommended loadings for the design of reinforced concrete chimneys and recommended methods for determining the stresses in the concrete and reinforcement resulting from these loadings. Charts containing curves to aid in the rapid solution of the specified formulas are included. While the method of analysis applies primarily to chimneys, it can be used for other hollow circular cross sections, with or without openings, where the shell thickness is small in proportion to the diameter.

Formulas are recommended for determining the temperature gradient through the concrete resulting from the difference in temperature of the gases inside the chimney and the surrounding atmosphere, together with methods for determining the stresses in the concrete and reinforcement both vertically and circumferentially due to the temperature gradient through the concrete.

Formulas for combining the stresses due to dead and wind (or earthquake) loads with the stresses due to temperature are included in the specification, together with recommended allowable stresses in the concrete and reinforcement for the various stress combinations.

The specification refers to the ACI "Building Code Requirements for Reinforced Concrete" (ACI 318) for applicable requirements with supplemental provisions to take care of the special requirements for concrete chimneys.

Appendices 1 and 2 review current (1968) practices for linings for concrete chimneys, for lightning protection, obstruction lighting, access ladders, and other chimney accessories.

ACI-ASCE Committee 428, Limit Design, has prepared "model clauses" in the area of its assigned mission. This report presents an amended and editorially corrected version of the fifth draft of the model clauses, and represents the committee's present progress in a continuing effort.

The model clauses presented can be used as the provisions for inelastic design in any code, but they are presented within the context of ACI 318-63 to give them a specific frame of reference. The committee presents them as if they were an additional chapter of the ACI Code in Part IV-B.

Following the model chapter, a commentary is presented which discusses each "section" of the chapter.

The suggested model clauses define envelopes, or upper and lower limits, rather than a single method of design. There is a section, however, which presents conditions to be satisfied regardless of method used. The model clauses can be used for each of the methods presented in recent years with only minor additions or adjustments to the method.

COMPRESSION SEALS FOR BRIDGES 65-62

Stewart C. Watson—Sept. 1968, pp. 721–729

Reviews the kinds of problems that develop when improper or inadequate joint sealing practices are used on bridges. Describes the many things to be considered when selecting a sealing system and shows how the trend to longer bridge spans require consideration of compression seals.

A brief review is given of practices in North America and Europe and several types of newly-developed compression seal systems are illustrated.

DESIGN PROCEDURES FOR COMPUTING DEFLECTIONS 65-53

Dan E. Branson—Sept. 1968, pp. 730–742

Presents design procedures for computing short-time and long-time deflections of noncomposite and composite ordinary reinforced and prestressed concrete beams. The paper discusses phases of the subject indicated in the ACI Building Code but not specifically defined therein, and is, in part, based on recent work of ACI Committee 435, Deflections.

EFFECT OF RUST AND SCALE ON THE BOND CHARACTERISTICS OF DEFORMED REINFORCING BARS 65-54

E. L. Kemp, F. S. Brezny, and J. A. Unterspan—Sept. 1968, pp. 743–756

An experimental program was established to provide needed information on bond characteristics of ASTM A 432 bars with a broad range of scale and rust conditions. The principle parameter in the test series was the bar surface conditions.

It was concluded that the bond characteristics of deformed reinforcing bars with deformations meeting ASTM A 305 specifications do not appear to be adversely affected by varying degrees or types of surface rust or ordinary mill scale provided the weight of the bar meets the minimum ASTM weight and deformation height requirements. The deformation dimensions appear to govern bond characteristics of rusty bars, in that these bars exhibit a behavior similar to companion "as rolled" bars. The test data indicate that the current bond requirements are quite conservative, especially with regard to smaller bars because of the 800 psi (nom. 60 kgf/cm^2) maximum stress limit. Concrete strength appears to control the over-all bond behavior, particularly slip and deformation, to a much greater extent than the surface condition of the bar.

NONLINEAR ANALYSIS OF REINFORCED CONCRETE BY THE FINITE ELEMENT METHOD 65-55

Arthur H. Nilson—Sept. 1968, pp. 757–766

Recent development of the finite element method of analysis permits consideration of members which are nonhomogeneous, defined by irregular boundaries, and arbitrarily supported and loaded. The continuum is replaced with a system of finite elements interconnected only at discrete points and the resulting structure is analyzed as a highly indeterminate system. The method is used to determine the internal stresses and displacements for reinforced concrete members subjected to progressively increasing load, with recognition of the several sources of nonlinearity. The resulting model permits accounting for (a) the influence of reinforcement, (b) changing topology due to progressive cracking, (c) realistic bond stress transfer between concrete and reinforcement, and (d) nonlinear material properties. Incremental loading permits study of member behavior through the entire range from zero load to ultimate.

HIGH STRENGTH BOLT SHEAR CONNECTORS —PUSHOUT TESTS 65-56

Lawrence N. Dallam—Sept. 1968, pp. 767–769

Presents static pushout tests of concrete-steel specimens using high strength bolts as shear connectors. The bolts were embedded in normal weight concrete and pretensioned by the turn-of-nut method after the concrete had aged 28 days. The length of bolt embedded was 4 in. (10.16 cm) within a 6 in. (15.24 cm) slab. Standard steel washers were spot welded under the heads of the bolts prior to installation. Twelve specimens were tested, four each with bolt diameters of ½, ⅝, and ¾ in. (1.27, 1.59, and 1.90 cm). Test results show very little slip between the slab and steel beam until friction is overcome. The bolts exhibited a greater useful capacity and ultimate strength than comparable studs.

CRITICAL STRESS, VOLUME CHANGE, AND MICROCRACKING OF CONCRETE . . . 65-57

Surendra P. Shah and Sushil Chandra—Sept. 1968, pp. 770–781

When concrete and mortar specimens are subjected to increasing uniaxial compression, their Poisson's ratios start to continuously and significantly increase on attaining a certain stress level called initiation stress. At a higher stress called critical stress, the volume of the concrete starts to increase rather than continuing to decrease. This inelastic behavior is due to the composite nature of concrete. Hardened paste specimens continue to consolidate at an increasing rate with increased load, and stone specimens show only a slight volume expansion at stresses near failure. Increasing the volume percentages of sand and gravel significantly reduces the percentage values of initiation stress and critical stress. Similarly, increasing the size of aggregate particles or reducing the strength of bond between aggregate and paste makes concrete more inelastic. A study of the correlation between external volume changes and internal microcrack propagation showed that the load at which the stress-volumetric strain curve deviates from linearity is related to a significant increase in microcracking at the aggregate-paste interface and that the stress at which volume begins to increase is related to a noticeable increase of microcracks through the matrix. Macroscopically, critical stress appears to be related to strengths of concrete under short-term, repetitive and long-time loading, and to fracture toughness, while microscopically, critical stress seems to indicate the beginning of significant slow crack growth.

CONSTRUCTION OF HABITAT '67 . . . 65-58

David J. Fitzgerald—Oct. 1968, pp. 801–810

Describes the conception, planning, design and construction of this featured structure at the 1967 World's Fair in Montreal.

SHEARHEAD REINFORCEMENT FOR SLABS 65-59

W. Gene Corley and Neil M. Hawkins—Oct. 1968, pp. 811–824

Tests of concentrically loaded slab-column specimens containing either lightweight or normal weight aggregate concrete and shearhead reinforcement made from structural shapes are briefly described. Based on the results of tests on these 21 specimens, a design procedure for shearheads at interior supports is proposed and a design example is presented. Strengths implied by this design procedure are compared with measured loads from tests described here and also with loads from other tests. The proposed design procedure is shown to provide shear capacity in the slab that is consistent with load factors and strength reduction factors being considered for use in the 1970 ACI Building Code.

CRACK CONTROL IN REINFORCED CONCRETE STRUCTURES 65-60

Edward G. Nawy—Oct. 1968, pp. 825–836

The cracking problem in concrete structures is becoming more critical because of the upgrading of the allowable stresses, strengths, and deflections, and using ultimate load procedures in design. Reasonable information exists on methods of crack control in reinforced concrete beams.

This paper deals with the present state of knowledge on cracking in concrete, procedures for crack control in exposed and protected structures, and improving flexural cracking behavior in beams, one-way slabs, and two-way slabs. Current acceptable expressions for determining crack width are applied to practical engineering designs. Also a discussion and tabulation of the permissible crack width in structures under different uses and exposures are presented.

SPIRALLY PRESTRESSED CONCRETE CYLINDERS. 65-61

C. W. Martin—Oct. 1968, pp. 837–845

Experiments with 17 spirally prestressed concrete cylinders are described. Spiral prestressing wire volume was 0.6 to 1.2 percent of concrete volume. Ultimate axial stress was increased 2.5 times but was virtually independent of lateral prestress. Axial stress at which Poisson's ratio deviated from a constant, axial stress at 0.05 percent offset and axial stress at minimum volume were increased by factors of 1.5 to 2.0 by lateral prestressing. Creep rupture occurred at 12.75 ksi (896.4 kgf/cm^2) axial stress but not at 5 ksi (351.5 kgf/cm^2). Four ksi axial compression might be a reasonable working stress for materials and percentages investigated.

STRENGTH, DURABILITY, AND SHRINKAGE OF INCOMPLETELY COMPACTED CONCRETE. 65-62

B. S. Heaton—Oct. 1968, pp. 846–850

An experimental investigation was carried out to determine the effects of different levels of compactive effort on the compressive strength, durability, and shrinkage of concrete over a range of workabilities.

Results show that even when increase in water content alone is used to increase workability, at low levels of compactive effort comparable with those used in normal building construction, maximum strength may be achieved with high workability high water content concrete.

DYNAMIC RESPONSE OF PRETENSIONED PRESTRESSED CONCRETE BEAMS. . . . 65-63

Wayne A. Hamilton—Oct. 1968, pp. 851–855

Seven pretensioned concrete beams were subjected to a highly impulsive load. The load, reaction, and displacement of the member were recorded. A comparison is made by determining the ratio of ultimate dynamic moment to ultimate static moment.

The test results show that the members will carry a 35 percent larger ultimate moment when applied dynamically.

STRENGTH AND MICROCRACKING OF PLAIN CONCRETE UNDER TRIAXIAL COMPRESSION. 65-64

K. T. Krishnaswamy—Oct. 1968, pp. 856–862

Concrete cubes were axially loaded in uniaxial and triaxial compressive loads separately. Slices were made from the strained specimen and these were examined for internal cracks using a microscope. By comparison of the internal microcracks in the two loading conditions an attempt has been made to explain the increase in the strength of concrete under triaxial compression.

RELATIONSHIP BETWEEN MOMENT CAPACITY AT FLEXURAL CRACKING AND AT ULTIMATE IN PRESTRESSED CONCRETE BEAMS 65-65

Ifedayo O. Oladapo—Oct. 1968, pp. 863–875

Presents an analytical study of the variation of the ratio of cracking moment to ultimate moment in prestressed concrete beams. The effect, on the ratio, of variations in the section properties, the limiting tensile stress of concrete and the level of prestress were investigated.

The analysis shows that there is a useful range for the steel ratio and that a limitation is necessary for the maximum as well as the minimum steel ratio. It is also shown that a direct control of cracking can be carried out, by stipulating a specified value for the ratio of cracking moment to ultimate moment and permissible stresses can be dispensed with in so far as they are indirect controls of cracking.

STRUCTURAL FABRIC REINFORCEMENT IN CONCRETE SLABS 65–66

Walter Podolny, Jr.—Oct. 1968, pp. 877–884

Discusses the manufacture, advantages, and applications of welded wire fabric as affected by pertinent sections of ACI 318-63. Describes the use of fabric in continuous one-way short-span slabs, in one-way corridor-type structures, long-span one-way slabs, two-way slabs, and as temperature reinforcement.

GUIDE FOR MAKING A CONDITION SURVEY OF CONCRETE IN SERVICE 65-67

ACI Committee 201—Nov. 1968, pp. 905–918

This guide provides a system for reporting on the condition of concrete in service. It includes a check list of the many details to be considered in making a report, and provides standard definitions of 40 terms associated with the durability of concrete. Its purpose is to establish a uniform system for evaluating the condition of concrete.

VARIABLE DEPTH FLOOR SLABS FOR PARKING GARAGE 65-68

E. Vernon Konkel and Nicholas V. Tsiouvaras—Nov. 1968, pp. 919–928

Describes the analysis, design, and construction of the variable depth floor slabs of the parking garage for the Chase Stone Center—Colorado Springs, Colo. Column centers are 30 ft each way and columns are structural steel. A typical slab is cast in place 24 in. deep at the columns and 7 in. at the center lines of the square panels. The undersurface of the slab is a hyperbolic paraboloid with sections parallel to the center lines as straight lines in both directions which results in a "hypar slab." This system is easy to form and results in several other economies that make the system desirable for structures of this type. The elastic frame method was used for both the applied loads and for the effect of the prestressing forces. Calculations are described in detail.

REVERSED CURVATURE OF TENDONS IN PRESTRESSED CONTINUOUS MEMBERS 65-69

Walter E. Riley—Nov. 1968, pp. 929–936

For any loading, it is possible in continuous prestressed concrete members to avoid secondary bending moments due to reversed curvature of tendon, if the tendon is placed to proper profile and consideration is given to the total effect of the forces of tendon on the concrete member. Examples of uniform loading, midpoint loading, and third-point loading are given.

USE OF SPIRAL WELDED STEEL TUBES IN PIPE COLUMNS 65-70

Noel J. Gardner—Nov. 1968, pp. 937–942

An experimental investigation into the structural behavior of concrete-filled spiral welded steel tubes under axial load is described. The experimental results are compared with the ACI-NBC (1967) requirements, with a previously proposed new ACI-NBC requirement and with the tangent moduli method. Results on the manufacturing stresses in the steel tubes are also given.

BEAM SHEAR STRENGTH PREDICTION BY ANALYSIS OF EXISTING DATA 65-71

Theodore C. Zsutty—Nov. 1968, pp. 943–951

An empirical method which combines the techniques of dimensional analysis and statistical regression analysis is applied to existing sources of reinforced concrete beam shear test data. For beams with a/d above 2.5, the method has produced failure stress prediction equations of the form $v = k\,(f'_c pd/a)^{1/3}$ for both cracking and sudden diagonal tension shear. These equations have a low percentage of prediction error for a wide range of beam properties and test sources. The high, but variable, shear failure stress of short beams with $a/d < 2.5$ has a lower bound given by the slender beam prediction equations. Further, short lateral stub beams, without top and bottom load and support block pressures, appear to have slender beam behavior.

WARPING AT THE EDGES OF PRESTRESSED AND REINFORCED CONCRETE PAVEMENT 65-72

Michel Amin Sargious—Nov. 1968, pp. 952–958

Deformations at the corners of prestressed and reinforced concrete slabs were measured to study warping and its effect on the strength of pavement for Kuwait International Airport. The principal variables for the prestressed pavement were the length of slab, concrete strength, and compressive stresses through prestressing forces. For the reinforced concrete pavements the principal variables were the location of the corners at which the measurements were taken.

The observations of the vertical movement due to warping at different times and different days were recorded and plotted in curves, for comparison between the vertical movement at the corners of the different slabs.

A limited study for the extension of the warping along the two perpendicular edges meeting at the corner was done in one case. Also, a loading test at the corner of only one slab was done for investigating the value of the load required to bring the corner down to contact point and to find out if any failure could take place at the corner under the design load.

DETERMINING THE TEMPERATURE HISTORY OF CONCRETE CONSTRUCTIONS FOLLOWING FIRE EXPOSURE 65-73

T. Z. Harmathy—Nov. 1968, pp. 959–964

With the use of thermogravimetry and dilatometry the maximum temperatures attained at various locations in a concrete construction during a fire can be determined, if samples of the concrete can be obtained within 1 or 2 days of the fire.

EFFECT OF ANCHORAGE EFFICIENCY OF LATERAL REINFORCEMENT ON THE TORSIONAL STRENGTH OF REINFORCED CONCRETE BEAMS. 65-74

V. Navaratnarajah—Nov. 1968, pp. 965–968

Two methods of anchorage of lateral reinforcement with longitudinal reinforcement in reinforced concrete beams, namely either tied or welded to each other, and their effects on the contribution of the reinforcement towards the ultimate torsional strength of the beams are discussed. Experimental results are presented which show the superiority of welding the lateral reinforcement to the longitiduinal reinforcement over the other method. Levels of strain in the lateral steel are shown to be at or above yield strains in welded beams, but below yield strains in tied beams. A modified expression for the ultimate torsional strength of welded rectangular reinforced concrete beams is suggested based on these findings.

PROPORTIONING FLY ASH CONCRETE MIXES FOR STRENGTH AND ECONOMY. 65-75

Robert W. Cannon—Nov. 1968, pp. 969–979

A method is presented for proportioning fly ash with cement to produce concrete of equal strengths at 28 and 90 days to concrete without fly ash. The method was developed by the Tennessee Valley Authority (TVA) as a result of using fly ash in all classes of concrete for the past 12 years. Effects of differing proportions of fly ash on water requirements, strength, and economy are given along with a discussion of the effects of fineness and carbon content of fly ash and variations in strength of cements on cement requirements. Comparisons are made between the cement requirements as determined by this method with the cement actually required by tests from the Corps of Engineers, TVA, and Bays Mountain Construction Company using at least nine different suppliers of cement and eight different fly ashes, four of which would not meet Federal and ASTM specifications.

EXPERIMENTAL STUDY OF REINFORCED CONCRETE FRAMES SUBJECTED TO ALTERNATING SWAY FORCES 65-76

Fred Beaufait and Ronald R. Williams—Nov. 1968, pp. 980–984

Presents a preliminary investigation studying the behavior of a reinforced concrete, pin-supported portal frame subjected to sway forces. The program involved the testing of seven frames: four frames were subjected to cyclic sway forces and three frames were loaded to failure with a single sway force. The objectives of this project were to study the influence of the placement of the reinforcing steel at the joints on the ultimate load capacity of the structure and to examine the effects of cyclic loading on the behavior of a reinforced concrete frame.

RECTANGULAR SPIRAL BINDERS EFFECT ON PLASTIC HINGE ROTATION CAPACITY IN REINFORCED CONCRETE BEAMS 65-77

Edward G. Nawy, Rodolfo F. Danesi, and John J. Grosko—Dec. 1968, pp. 1001–1010

Limit design of concrete indeterminate structures is based on rotation-compatibility of the plastic hinges. Improved rotation capacity of the hinges permits better redistribution of moments and higher reserve strength of structural systems. This investigation deals with the use of rectangular spiral binders for confining the concrete in beams to increase the rotation capacity of the plastic hinge. These spirals serve simultaneously as diagonal tension reinforcement.

Two series were tested: tension hinges in beams 84 in. (2.1 m) span subjected to transverse load only, and compression hinges in beams 80 in. (2.0 m) span subjected to both transverse and axial load. It is found that rectangular spirals are very effective in increasing the rotation capacity of tension and compression plastic hinges. A possible maxi-

mum effective percentage by volume of rectangular spirals for p'' seems to be about 3.0 percent for tension hinges and slightly more than 2.0 percent for compression hinges.

CORROSION OF STEEL IN LIGHTWEIGHT CONCRETE SPECIMENS 65-78

S. B. Helms and A. L. Bowman—Dec. 1968, pp. 1011–1016

Severe corrosion of reinforcement in channel slabs of a roof structure was reproduced by cyclic exposure of laboratory molded prisms and cylinders containing steel inserts. Earlier studies using small cylinders showed that the first indications of corrosion would be evident after 50 cycles of wetting and drying.

Specimens exposed to daily cycles involving directional exposure to condensation and saturation at elevated temperatures show 100 cycles adequate to determine the absence of any corrosive tendency.

While the presence of two percent calcium chloride may not be corrosive in more favorable environments, the results indicate that for severe exposure to moisture and temperature changes the safe practice is to use materials known to be free of chlorides. Inserts in control specimens containing no chloride accelerator were free of corrosion, with either of two types of lightweight aggregates, even after 150 cycles of exposure.

STRUCTURAL DESIGN CONSIDERATIONS FOR SETTLING TANKS AND SIMILAR STRUCTURES 65-79

Anand B. Gogate—Dec. 1968, pp. 1017–1020

Reviews available literature on the analysis and design of concrete settling tanks and similar structures. Recommended procedures for design are discussed in the light of modern research. New criteria for code design provisions based on crack widths and crack spacing are suggested. A comparison is made of the concrete tank with a conventional structure in areas where special provisions are needed.

HYDROGEN EVOLUTION FROM FERROPHOSPHOROUS AGGREGATE IN PORTLAND CEMENT CONCRETE 65-80

T. G. Clendenning, B. Kellam, and C. MacInnis—Dec. 1968, pp. 1021–1028

Hydrogen evolution in a heavy concrete containing ferrophosphorus aggregate was noted during construction of a biological shield for a nuclear generating station. While the reaction was of a self-limiting nature, the concrete would produce over 25 times its volume of hydrogen before the reaction ceased. The factors affecting the reaction and the possible mechanisms involved are discussed. Subsequent investigation has shown that a similar reaction occurs with ferrosilicon, another heavyweight slag, otherwise of potential value in heavy concrete.

ULTIMATE STRENGTH ANALYSIS OF COUPLED SHEAR WALLS 65-81

Arnold Winokur and Jacob Gluck—Dec. 1968, pp. 1029–1036

Presents an ultimate strength method to analyze coupled shear walls. The collapse mechanism is assumed to have plastic hinges at the points of contact of the connecting beams and the shear wall and at the bottom of the latter. The method is applicable to multistory structures comprising different types of simple and coupled shear walls with or without abrupt changes in cross section.